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Nos. 351–375,

WITH CONTENTS AND INDEX.

PREPARED UNDER THE SUPERVISION OF
JOSEPH A. ARNOLD,
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CONTENTS.

FARMERS' BULLETIN No. 351.—THE TUBERCULIN TEST OF CATTLE FOR TUBERCULOSIS.

Page.
The diagnosis of tuberculosis........ 3
The origin of the tuberculin test........ 3
The nature and application of tuberculin........ 3
The value and reliability of the tuberculin test........ 4
The harmlessness of tuberculin........ 6
Disposal of and indemnity for reacting animals........ 7
Conclusions regarding the tuberculin test........ 7
Summary of directions for making the tuberculin test........ 8

FARMERS' BULLETIN No. 352.—THE NEVADA MOUSE PLAGUE OF 1907-8.

Introduction........ 5
The mouse plague in Humboldt Valley........ 5
A plague threatened in Carson Valley........ 10
Previous outbreaks........ 10
Origin and progress of such plagues........ 11
The species responsible for the plague........ 12
Repressive measures........ 13
Natural enemies of field mice........ 21
Conclusions........ 22

FARMERS' BULLETIN No. 353.—EXPERIMENT STATION WORK, L.

Commercial clover seed........ 5
Dodder in alfalfa seed........ 7
Growing potatoes under straw........ 9
Hens versus incubators........ 10
Preparing fowls for market........ 12
Preservation of eggs........ 14
The mound-building prairie ant........ 15
Effect of glass, metals, etc., on coagulation of milk in cheese making........ 17
The effect of alkali on cement structures........ 20
Silo construction........ 22
A cheap and efficient sterilizer........ 27
A cheap and efficient ice box........ 29
The power laundry for the farm........ 31

FARMERS' BULLETIN No. 354.—ONION CULTURE.

Introduction........ 5
Areas adapted to onion culture........ 6
Cultural methods........ 8
The production of Bermuda onions........ 30
Green onions for bunching........ 32
Enemies of the onion........ 33
Summary........ 36

FARMERS' BULLETIN No. 355.—A SUCCESSFUL POULTRY AND DAIRY FARM.

Introduction........ 5
History of the farm and its owner........ 6
Hours of labor........ 8
Drainage........ 9
The cropping system........ 9
The silo and the silage crops........ 11
The handling of manure........ 12
The dairy herd and its management........ 12
Hogs........ 20
Poultry........ 21
Work stock........ 40
Concluding remarks........ 40

Farmers' Bulletin No. 356.—Peanuts.

Page.

Introduction 7
Soil and climatic requirements of the peanut 8
Preparation of the soil 10
Fertilizers and preparatory crops 11
The seed and its selection 13
Time and methods of planting 15
General cultivation 17
Harvesting 19
Picking and cleaning 23
Varieties of peanuts 27
The uses of the peanut 31
The importance of the peanut as a farm crop 35
Insects injurious to the peanut 38
Diseases of the peanut 38
Conclusions 39

Farmers' Bulletin No. 357.—Methods of Poultry Management at the Maine Agricultural Experiment Station.

Introduction 5
The selection of breeding stock 5
Raising chickens by natural processes 6
Raising chickens by artificial processes 8
Feeding chickens on the range 17
Feeding cockerels for market 19
Housing the hens 20
The yards 31
Feeding the hens 31
A poultry-house disinfectant 34
Trap nests 36

Farmers' Bulletin No. 358.—A Primer of Forestry, Part II: Practical Forestry.

Forest management 3
Work in the woods 21
The weather and the streams 29
Forestry abroad and at home 40

Farmers' Bulletin No. 359.—Canning Vegetables in the Home.

Introduction 5
The science of sterilization 5
Exclusion of the air 7
So-called "Preserving Powders" 8
Kinds of jars 8
Containers for sterilizing 10
Selection and preparation of vegetables 10
Freshness of flavor and color 15
How to open a jar 16
Cautions 16

Farmers' Bulletin No. 360.—Experiment Station Work, LI.

Distance between corn hills 5
The bursting of carnations 7
Street trees, care and preservation 9
Spraying for weeds 15
Market classes and grades of sheep 17
Vetch hay and vetch silage as feeds for cows 29
Digestibility of kale 30
Hulled corn 31
Methods of mixing fat into dough 32

Farmers' Bulletin No. 361.—Meadow Fescue: Its Culture and Uses.

Introduction 5
Culture of meadow fescue 8
Enemies of meadow fescue 14
Meadow fescue in the East 16
Present importance and future of meadow fescue 18
Tall fescue 19
Summary 22

FARMERS' BULLETIN NO. 362.—CONDITIONS AFFECTING THE VALUE OF MARKET HAY. Page.

Factors influencing the hay industry........ 7
Southern hay trade........ 9
Tame hay areas of the United States........ 9
Increase in yield per acre of hay from 1865 to 1905........ 10
Price of hay for forty years........ 13
Increasing value of hay lands........ 13
Fertilizing elements in hay........ 14
Need of suitable rotations for hay lands........ 15
Nutritive substances in hay........ 16
Palatability of hay........ 17
Digestibility of hay........ 18
Aroma of hay........ 19
Grassy and weedy hay........ 19
Low-grade hay on the market........ 21
Value of low-grade hay........ 23
Grades of hay adopted by the National Hay Association........ 23
Loss caused by stacking hay........ 25
Value of clover hay........ 27
Conclusions........ 27

FARMERS' BULLETIN NO. 363.—THE USE OF MILK AS FOOD.

Introduction........ 7
Sources and kinds of milk........ 8
Composition and characteristics of milk........ 9
Preserving milk........ 15
Condensed milk and milk powder........ 18
Graded and certified milk........ 19
Care of milk in the home........ 20
Digestibility of milk........ 20
Relative value of cooked and raw milk........ 23
Milk for infants—Modified milk—Homogenized milk........ 25
Special infant foods........ 26
Nutritive value of milk compared with other foods........ 27
Cost of nutrients in whole milk and skim milk........ 33
The use of milk in cooking........ 35
Milk products........ 36
Summary........ 42

FARMERS' BULLETIN NO. 364.—A PROFITABLE COTTON FARM.

Introduction........ 7
Description of the cotton farm........ 7
Management of the farm........ 8
Plowing........ 9
Surface drainage........ 10
Methods of growing the crops........ 10
Live stock........ 17
Equipment of the farm........ 18
Cost and value of crops produced in 1908........ 18
Use of fertilizers........ 19
Recommendations regarding winter cover crops........ 21
Summary........ 21
Some features of the system of management described applicable to many farms........ 23

FARMERS' BULLETIN NO. 365.—FARM MANAGEMENT IN NORTHERN POTATO-GROWING SECTIONS.

Introduction........ 5
Methods employed in growing potatoes in Aroostook County, Maine........ 7
Methods employed in growing potatoes in other sections........ 16
Cost of producing potatoes........ 20
Problems confronting Aroostook County growers........ 22
Seed selection........ 26
Conclusions........ 28

FARMERS' BULLETIN NO. 366.—EXPERIMENT STATION WORK, LII.

Treatment of muck soils........ 5
Manures for timothy hay........ 6
Ten generations of corn breeding........ 10
Yellow berry in hard winter wheats........ 13

FARMERS' BULLETIN No. 366.—EXPERIMENT STATION WORK, LII—Cont'd. Page.
Weed seeds in feeding stuffs........ 16
Hook-worm disease of cattle........ 17
Effect of machine milking of individual cows........ 19
Milk supply of cities........ 20
The crow as a menace to poultry raising........ 28
Hours of labor, wages, and cost of board on Minnesota farms........ 30

FARMERS' BULLETIN No. 367.—LIGHTNING AND LIGHTNING CONDUCTORS.
Introduction........ 7
Origin of electricity........ 8
Conductors and nonconductors........ 8
Positive and negative electrification........ 8
Electricity in thunderstorms........ 11
Lightning rods for farm buildings........ 14

FARMERS' BULLETIN No. 368.—THE ERADICATION OF BINDWEED, OR WILD MORNING-GLORY.
Introduction........ 5
Injurious effects of bindweed........ 5
Distribution........ 7
Description........ 8
Methods of eradication........ 10
Summary........ 18

FARMERS' BULLETIN No. 369.—HOW TO DESTROY RATS.
Introduction........ 5
Means of repressing rats........ 6
Summary of recommendations........ 19

FARMERS' BULLETIN No. 370.—REPLANNING A FARM FOR PROFIT.
Introduction........ 5
Difficulty of taking up a new line of farming........ 5
How shall the change be made?........ 5
Objections to giving advice on the management of entire farms........ 6
Farm plans must be based on average conditions........ 7
How farms are replanned by the office of farm management........ 7
Replanning a farm in central Illinois........ 8
Summary of returns from different types of farming........ 33
Plans given not model plans........ 34
The problem of replanning a farm........ 35
Why low returns are realized from some farms........ 35
Summary........ 36

FARMERS' BULLETIN No. 371.—DRAINAGE OF IRRIGATED LANDS.
Introduction........ 5
Cache County [Utah] investigations........ 7
Boxelder County [Utah] investigations........ 11
Investigations in Weber and Davis counties [Utah]........ 18
Emery County [Utah] investigations........ 25
Sevier County [Utah] investigations........ 32
Washington County [Utah] experiment........ 35
Drainage of irrigated lands in other States........ 44
Principles and practice........ 45
Summary........ 51

FARMERS' BULLETIN No. 372.—SOY BEANS.
Introduction........ 5
Climatic and soil requirements of soy beans........ 6
Varieties of soy beans........ 7
The culture and planting of soy beans........ 11
The inoculation of soy beans........ 12
Soy beans for hay........ 14
Soy beans for pasturage........ 15
Soy beans in mixtures........ 16
Soy beans for ensilage........ 18
Soy beans for grain........ 18
Soy beans in rotations........ 20
Feeding value of soy beans........ 20
Storing soy-bean seed........ 22
Comparison of soy-bean grain and cotton-seed meal........ 23
Comparison of soy beans and cowpeas........ 24
Summary........ 25

Farmers' Bulletin No. 373.—Irrigation of Alfalfa.

Page.
Introduction........ 7
Irrigable lands adapted to alfalfa........ 8
The removal of native vegetation........ 10
Preparatory crop........ 12
Methods of irrigating alfalfa........ 13
Farm ditches........ 31
The subirrigation of alfalfa fields........ 35
Amount of water required........ 38
The proper time to irrigate alfalfa........ 40
Winter irrigation of alfalfa........ 41
Winterkilling of alfalfa........ 41
Seeding alfalfa on land to be irrigated........ 43
Rise of ground water and its effects on alfalfa........ 44
The injurious effect of silt on alfalfa and the benefits to be derived from disking........ 46
Pasturing irrigated alfalfa........ 46
Production of alfalfa seed under irrigation........ 47
Profits to the irrigator........ 47

Farmers' Bulletin No. 374.—Experiment Station Work, LIII.

Inoculation and lime for alfalfa........ 5
Citrus culture in southern Texas........ 7
Pruning rotundifolia grapes........ 11
Nutritive value of native hays in the arid regions........ 12
Bermuda grass........ 16
Short versus long feeding of beef cattle........ 17
Contagious abortion of cattle........ 19
Preventing losses at lambing time........ 22
Winter lambs for the Pacific coast market........ 25
Feeding work horses........ 25
Colony houses for poultry........ 26
Food of the crow blackbird........ 30
Flour for making baking-powder biscuits........ 31

Farmers' Bulletin No. 375.—Care of Food in the Home.

Introduction........ 7
Yeasts, molds, and bacteria, and the spoiling of food........ 7
Flies and food........ 14
Dust in its relation to food........ 17
Pet animals in the kitchen........ 18
The food supply........ 19
The storage of food........ 26
The keeping of vegetables, fruits, and meats........ 33
Storage of groceries, meats, cooked food, and canned goods........ 34
Care and utilization of fats........ 37
Handling of food and utensils in the kitchen........ 38
Importance of good house plans and home conveniences........ 44
Cleanliness in public eating places........ 45

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 351.

THE TUBERCULIN TEST OF CATTLE FOR TUBERCULOSIS.

BY

JOHN R. MOHLER, A. M., V. M. D.,
Chief of the Pathological Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 30, 1908.

Sir: I have the honor to transmit herewith a paper on The Tuberculin Test of Cattle for Tuberculosis, by Dr. John R. Mohler, Chief of the Pathological Division of this Bureau.

Tuberculosis of cattle, although not so prevalent in the United States as in some other countries, nevertheless exists here to an alarming extent, especially in some States where no steps have been taken for its suppression. It is estimated that on an average not less than 1 per cent of the beef cattle and 10 per cent of the dairy cattle in the country are affected with this disease, and in some localities the percentages are very much higher. The financial loss from tuberculosis in live stock is not less than $14,000,000 annually.

As the first step in any measure for eradication, either by public authorities or by private owners, it is necessary that there should be some accurate and reliable method of diagnosis. In the great majority of cases it is impossible to detect the disease in the living animal by ordinary physical examination. The tuberculin test, as pointed out by Doctor Mohler, affords the most reliable known method for detecting tuberculosis in cattle, records having proved its accuracy in over 97 per cent of cases, and it has the additional advantage of being harmless.

It is important, however, that a reliable tuberculin be used, as experiments by this Bureau have shown that some of the tuberculin on the market is impotent and worthless. It seems likely that some of the dissatisfaction occasionally experienced with the tuberculin test is due to this fact. The Bureau of Animal Industry prepares a trustworthy tuberculin and furnishes it free of charge to health officers and other public authorities under certain conditions for official use. The Bureau can not, however, supply tuberculin on any terms for private use.

The accompanying paper was included in the Twenty-fourth Annual Report of this Bureau, but in order to make it available for wide distribution in pamphlet form I respectfully recommend its publication also in the Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

THE TUBERCULIN TEST OF CATTLE FOR TUBERCULOSIS.

THE DIAGNOSIS OF TUBERCULOSIS.

The symptoms of tuberculosis in cattle are not sufficiently prominent, except in advanced stages or when superficially located, to enable one to diagnose this disease by the ordinary methods of physical examination. And the cattle may, without showing any clinical symptoms, be in such a stage of tuberculosis as to render them capable of spreading disease. Indeed, an animal may be fat and sleek, eat and milk well, have a bright, glossy coat, and be apparently in the pink of condition, and still be passing tubercle bacilli through the feces or by an occasional cough, and thus endanger all the healthy cattle in the herd. Consequently such adventitious aids to diagnosis as animal inoculation, biological test, serum agglutination reaction, and the tuberculin test are made use of in arriving at a definite opinion relative to the presence or absence of this disease. The value of all but the last of these is discounted by the technique required and by their impracticability, while the tuberculin test is most satisfactory and is the best diagnostic agent known for the disease.

THE ORIGIN OF THE TUBERCULIN TEST.

Tuberculin was invented by Koch in 1890, and was first used experimentally in treating tuberculosis in man. In these cases it was observed that its injection was followed by a rise of temperature, which led veterinarians to apply tuberculin to suspected animals to see if a similar reaction resulted. Numerous experiments showed this to be the case, and since 1891 the use of tuberculin as a diagnostic agent for tuberculosis of cattle has been almost universally adopted in all parts of the civilized world. No one thinks of accepting tuberculin as an absolutely infallible agent, but it is immeasurably more dependable than any other method that has ever been used.

THE NATURE AND APPLICATION OF TUBERCULIN.

Tuberculin is the sterilized and filtered glycerin extract of cultures of tubercle bacilli. It contains the cooked products of the growth of these bacilli, but not the bacilli themselves. Consequently, when this substance is injected under the skin of an animal it is absolutely unable to produce the disease, cause abortion, or otherwise injure the animal. In case the injected animal is normal there is no more effect upon the system than would be expected from the injection of sterile water. However, if the animal is tuberculous, a decided rise of temperature will follow the use of tuberculin.

In practice the tuberculin test is applied by first taking a sufficient number of temperatures, usually three, at intervals of two hours to ascertain the normal variation of temperature of the animal to be tested. The dose of tuberculin (which should always be specified on the label) is then injected hypodermically between 8 and 10 p. m. on the day of taking the preliminary temperatures.[a] On the following day the "after" temperatures are recorded every two hours, beginning at 6 a. m. and continuing until twenty hours following the injection.

THE VALUE AND RELIABILITY OF THE TUBERCULIN TEST.

As a result of this method an accurate diagnosis may be established in over 97 per cent of the cases tested.[b] The relatively few failures in diagnosis are included among two classes of cattle. The first class contains those that are tuberculous but which do not react either because of the slight effect of an ordinary-sized dose of tuberculin on an advanced case of the disease with so much natural tuberculin already in the system, or on account of a previous test with tuberculin which produces a tolerance to this material lasting for about six weeks. The second class includes those that are not tuberculous but which show an elevation of temperature as a result of (*a*) advanced pregnancy; (*b*) the excitement of œstrum; (*c*) concurrent diseases, as inflammation of the lungs, intestines, uterus, udder, or other parts, abortion, retention of afterbirth, indigestion, etc.; (*d*) inclosure in a hot, stuffy stable, especially in summer, or exposure to cold drafts or rains; or (*e*) any change in the method of feeding, watering, or stabling of the animal during the test.

---

[a] Great interest has been manifested recently in the cuti tuberculin test of Von Pirquet and the ophthalmo tuberculin test of Wolff-Eisner and Calmette. As their names imply, these tests consist in the application of the tuberculin to the eye and to the scarified skin, respectively, of the animal to be tested. The very favorable results which were reported from the application of both of these methods excited a great deal of interest among investigators, and soon numerous results of the experiments were published, which, however, were not uniformly favorable for either of the tests.

The best results were apparently obtained from the ophthalmo reaction. The changes in the eye resulting from a marked reaction are characteristic; intolerance to light and an increased secretion of tears are the first indications, which may be followed by more severe symptoms, as marked congestion of the conjunctiva, a whitish film-like exudate over the bulbar conjunctiva, and a grayish yellow discharge from the eye, which, running down the face, forms crusts. The test is applied to only one eye, and in the reaction the other or control eye should remain normal.

Thus far the ophthalmo and cuti tuberculin tests can not be recommended for general practice as methods of diagnosing tuberculosis of bovines, and they will require further work and perfection before they should pass from the experimental stage and be adopted in place of the present reliable subcutaneous application.

[b] Reports of tuberculin tests made in the fifteen years from 1893 to 1908 by Federal, State, and other officers with tuberculin prepared by the Bureau of Animal Industry show that out of 24,784 reacting cattle slaughtered, lesions of tuberculosis were found in 24,387, a percentage of 98.39.

Notwithstanding all these possibilities of error, the results of thousands of tests show that in less than 3 per cent of the cases tested do these failures actually occur. In the first class the chances of error are decidedly reduced by the skilled veterinarian by making careful physical examination and diagnosing these advanced cases, and by the injection of double or triple doses into all recently tested cattle, with the taking of the after temperatures beginning two hours following the injection and continuing hourly for twenty hours. In the second class errors are avoided by eliminating those cases from the test that are nearing parturition or are in heat, or show evidence of the previously mentioned diseases, or exhibit temperatures sufficiently high to make them unreliable for use as normal. Then, in reading after temperatures it is advisable not to recognize as a reaction an elevation of temperature less than 2° F., or one which at the same time does not go above 103.8° F., and the temperature reaction must likewise have the characteristic rainbow curve. (Those cases which approximate but do not reach this standard should be considered as suspicious and held for a retest six weeks later.) In addition, a satisfactory tuberculin must be used, also an accurate thermometer and a reliable syringe in order that a sufficient dose of tuberculin may be given. Finally, the number of apparent errors of the tuberculin test will be greatly diminished if a careful post-mortem examination is made, giving especial attention to the lymph glands.

This low percentage of failures being the case, cattle owners should welcome the tuberculin test not only for their own interest but for the welfare of the public as well. Where this method of diagnosing the disease has been adopted tuberculosis is gradually being eradicated, while it is spreading rapidly and becoming widely disseminated in those districts where the tuberculin test has not been employed. Without its use the disease can not be controlled and the cattle owner is confronted with serious and continuous losses; with its use the disease can be eradicated from the herd, a clean herd established, and the danger of its spread to man removed. Tuberculin may, therefore, be considered a most beneficial discovery for the stock raiser. Strange to say, many of these men have been incredulous, antagonistic, or prejudiced against the tuberculin test by misinterpreting published statements, by incorrect, unsubstantiated, or exaggerated reports, and by alleged injurious effects to healthy cattle.

Law[a] has clearly stated the question when he says:

> Many stock owners still entertain an ignorant and unwarranted dread of the tuberculin test. It is true that when recklessly used by ignorant and careless people it may be made a root of evil, yet as employed by the intelligent and careful expert it is not only perfectly safe, but it is the only known means of ascertaining approximately the actual number affected in a given herd. In most infected herds, living under what are in other respects good hygienic conditions, two-thirds or three-fourths are not to be detected without its aid, so that in clearing a herd from tuberculosis, and placing both herd and products above suspicion, the test becomes essential.
>
> * * * * * * *
>
> In skilled hands the tuberculin test will show at least nine-tenths of all cases of tuberculosis when other methods of diagnosis will not detect one-tenth.

It is perfectly natural that there should be objection to its use among those who are not acquainted with its method of preparation or its properties; but it is difficult to explain the antagonism of farmers who are familiar with the facts connected with the manufacture and use of tuberculin. Probably the most popular objection to tuberculin is that it is too searching, since it discovers cases in which the lesions are small and obscure. While this fact is admitted, it should also be borne in mind that such a small lesion to-day may break down and become widely disseminated in a relatively short period. Therefore any cow affected with tuberculosis, even to a slight degree, must be considered as probably dangerous not only to the other animals in the herd but also to the consumer of her products.

THE HARMLESSNESS OF TUBERCULIN.

Furthermore, tuberculin must be considered as harmless for healthy animals in view of the results revealed by numerous tests covering vast numbers of animals. And it has also been clearly demonstrated that tuberculin interferes in no way with the milking function in healthy cattle; neither in the quantity of milk nor in butterfat value has any variation been detected.

Nocard and Leclainche[b] state:

> Direct experiments and observations collected by thousands show that the tuberculin injections have no unfavorable effect. With healthy animals the system is indifferent to the inoculation; with tuberculous animals it causes only slight changes, which are not at all serious.

---

[a] Text Book of Veterinary Medicine, vol. 4, pp. 458, 465. Ithaca, N. Y., 1902.

[b] Les Maladies Microbiennes des Animaux, vol. 2, p. 85. Paris, 1903.

DISPOSAL OF AND INDEMNITY FOR REACTING ANIMALS.

Most of the objections to tuberculin would probably be removed if some method of compensation for the reacting animals could be devised. Thus, in Pennsylvania, where tuberculosis is being eradicated with more success than in any other State, and where there are usually three times as many voluntary requests on file for the application of the test as can be made, all reacting animals are paid for by the State. As the suppression of tuberculosis is a public health measure, it would appear perfectly logical for the State governments to reimburse cattle owners appropriately for the animals condemned and slaughtered. Provision could be made to pay 70 per cent of the appraised value of the condemned animals, not to exceed $30 a head for common stock or $60 for registered stock. Such legislation should also include a requirement for the testing of all dairy and breeding cattle coming into the State.

All tuberculous animals should be slaughtered in abattoirs having competent inspection, and the money obtained from those slight and localized cases which are inspected and passed for food and from the hide and offal of those carcasses condemned as unfit for food should be applied as part payment on the indemnity for their respective owners. The payment of indemnity for tuberculous animals is a good business policy and would do more toward making the tuberculin test popular with cattle owners than any other possible action. And as a corrollary of the latter, more testing would be performed and more tuberculous cattle would be discovered at the start, but the gradual suppression of the disease would soon be manifest, as has been noted in Pennsylvania and Denmark. Furthermore, as Stiles has mentioned, if tuberculosis can be eradicated from dairy herds with but slight loss to the owner, the increase in the price of milk would naturally be inhibited, and the children of poor families would consequently be in less danger of having this very important article of their diet decreased.

CONCLUSIONS REGARDING THE TUBERCULIN TEST.

As a result of the careful study of the tuberculin test, Salmon[a] draws the following conclusions:

1. That the tuberculin test is a wonderfully accurate method of determining whether an animal is affected with tuberculosis.
2. That by the use of tuberculin the animals diseased with tuberculosis may be detected and removed from the herd, thereby eradicating the disease.

---

[a] Yearbook of the United States Department of Agriculture, 1901, p. 592.

3. That tuberculin has no injurious effect upon healthy cattle.
4. That the comparatively small number of cattle which have aborted, suffered in health, or fallen off in condition after the tuberculin test were either diseased before the test was made or were affected by some cause other than the tuberculin.

SUMMARY OF DIRECTIONS FOR MAKING THE TUBERCULIN TEST.

1. Stable cattle under usual conditions and among usual surroundings, feeding and watering in the customary manner.
2. Make a physical examination of each animal, and give to each one some designation by which the animal will be known throughout the test.
3. Take each animal's temperature at least three times at two or three hour intervals on the day of injection; for instance, at 2, 5, and 8 p. m.
4. At 8 or 10 p. m. inject a dose of tuberculin under the skin in the region of the shoulder, using a sterile hypodermic syringe after disinfecting the skin at the seat of injection with a 5 per cent solution of carbolic acid or a similar antiseptic solution.
5. Tuberculin is not always concentrated to the same degree, and therefore the dose, which should always appear on the label, varies considerably. The dose of imported tuberculin is 0.25 c. c. for an adult cow, and before injection is diluted with sterile water to 2 c. c. The tuberculin made by the Bureau of Animal Industry is prepared so that it will not be necessary to dilute it, and the dose is 2 c. c. for an adult animal. Yearlings and 2-year-olds, according to size, should receive from 1 to 1½ c. c., while bulls and very large animals may receive 3 c. c.
6. At 6 a. m. on the day following the injection of tuberculin commence taking temperatures, and continue every two or three hours until the twentieth hour after injection, at which time if there is no tendency for the temperature to rise the test may cease.
7. A rise of 2° F. or more above the maximum temperature observed on the previous day, providing the temperature after injection exceeds 103.8° F., should be regarded as an indication of tuberculosis. Those cases which approximate but do not reach this standard should be considered as suspicious and held for a retest six weeks later, giving double the original dose.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 352.

THE NEVADA MOUSE PLAGUE OF 1907-8.

BY

STANLEY E. PIPER,

Assistant, Biological Survey.

WASHINGTON:
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
Washington, D. C., January 12, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a report on the Nevada Mouse Plague of 1907–8, by S. E. Piper, an assistant in the Biological Survey.

The report is important from three points of view: (1) It is the first account we have ever had of a fully developed mouse plague in America; (2) it shows that such plagues may be successfully combated; and (3) it emphasizes the necessity for protecting our native hawks and owls and the smaller predatory mammals in order to prevent the recurrence of such plagues in future.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 5

The mouse plague in Humboldt Valley 5

  History of the outbreak 5

  Efforts of ranchmen to combat the plague 7

  How the outbreak was finally controlled 8

  Estimates of damage 9

A plague threatened in Carson Valley 10

Previous outbreaks 10

Origin and progress of such plagues 11

The species responsible for the plague 12

Repressive measures 13

  Poisons 13

    Phosphorus 13

    Strychnine 13

  Baits for the administration of poisons 14

    Alfalfa hay 14

    Green alfalfa 16

    Crushed wheat 17

  Obliterating burrows 17

  Irrigation 18

  Winter flooding 19

  Burning 19

  Destruction of winter cover 19

  Protection of trees 20

  Dogs as mouse destroyers 20

  Summary of repressive measures 20

Natural enemies of field mice 21

Conclusions 22

ILLUSTRATIONS.

Page.
FIG. 1. Alfalfa plant killed by field mice........ 6
2. Alfalfa field ruined by mice........ 7
3. Lombardy poplar girdled and killed by field mice........ 8
4. The Carson field mouse (*Microtus montanus*)........ 12
5. Men distributing poison........ 15
6. Where to place poison........ 15
7. Field mice poisoned by green alfalfa........ 16
8. Brush drag used to obliterate mouse holes........ 18
9. Effect of brush drag, showing mouse holes in part not dragged........ 18

THE NEVADA MOUSE PLAGUE OF 1907-8.

INTRODUCTION.

This bulletin gives an account of the recent mouse plague in Humboldt Valley, Nevada. Its object is to acquaint farmers with the dangers from field mice and to describe the best methods of destroying and controlling the animals. Though referring particularly to the Nevada outbreak, the recommendations apply to similar species in other parts of the United States.

THE MOUSE PLAGUE IN HUMBOLDT VALLEY.

HISTORY OF THE OUTBREAK.

Damage by field mice attracted the attention of the ranchmen in the lower part of Humboldt Valley early in the spring of 1906 and became severe during the following summer.[a] In the fall and winter of 1906–7, damage had increased until fields here and there in the valley were seriously injured. Extensive ravages first occurred above and about Lovelocks. In May, 1907, fields on the Rodgers ranch, 5 miles below Lovelocks, were invaded from the lands farther up the valley, the progress of the mice being plainly marked, as the fields above the Rodgers ranch suffered first. The movement of this great body of mice, it should be noted, was a gradual, scattering progression, first by a few and later by increasing numbers, until the greater part had moved to fresh fields. Numbers, however, finding conditions improved, remained as stragglers in the fields deserted by the main body.

By October, 1907, a large part of the cultivated lands in this district had been overrun by vast numbers of mice. The yield of hay had been reduced by one-third; potatoes and root crops were largely destroyed; many alfalfa fields were ruined by the mice eating the roots of the plants; and the complete destruction of this, the chief crop in the valley, was threatened.

The height of abundance was reached in November, when it was estimated that on many large ranches there were from 8,000 to 12,000 mice to each acre.[a] The fields were riddled by their holes, which were scarcely a step apart, and over large areas averaged 150 to 175 to the square rod. Ditch embankments were honeycombed, and the scene was one of devastation. Serious losses in hay and root crops during the summer proved but a slight forerunner of the damage which began in the fall with the disappearance of green food. Burrowing down about the plants, and extending their underground runs from root to root, they either killed or seriously injured the alfalfa (fig. 1). By November they had destroyed so large a percentage of the plants that many fields were plowed up as hopelessly ruined (see fig. 2). They attacked also the roots of trees, seriously injuring or quite destroying orchards. They killed most of the young shade trees planted along ditches, and so completely girdled large Lombardy and silver poplars (fig. 3) that in some cases they caused the death of even such hardy trees.

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[a] Reported by J. S. Cotton, Sept., 1906.

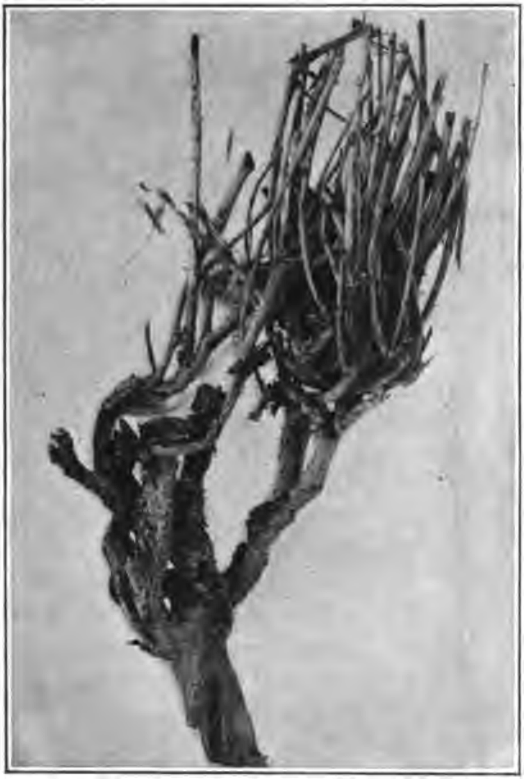

FIG. 1.—Alfalfa plant killed by field mice.

By January, 1908, in fields where the mice had existed by thousands the previous summer and fall, comparatively few, possibly 200 to 500 to each acre, remained. The border of the destroyed district was about 6 miles below Lovelocks, and the mice were gradually moving further down the valley. In the area below this, mice were somewhat in excess of normal numbers and in several centers of abundance had seriously injured fields. Even where most abundant, along the lower border of the affected area, they did not exceed 1,500 to the acre. In the winter they attacked every available food supply. Small willows and even greasewood bushes about the borders of fields were stripped of all the bark within reach, and horse and cattle droppings were gnawed to pieces for the food they contained. Alfalfa roots, however, were the food supply on which the mice were chiefly dependent.

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[a] Reported by Vernon Bailey, Nov., 1907.

EFFORTS OF RANCHMEN TO COMBAT THE PLAGUE.

In Nevada, the great majority of ranchmen knew neither what to expect from such great numbers of mice nor how to check them. It must be said, however, that no previous examples of successfully controlling such plagues exist; usually they have run their courses until brought to an end by natural agencies. Hence it is not surprising that in Humboldt Valley no concerted or systematic efforts to suppress the plague in its earlier stages were undertaken, but after the mice swarmed in thousands over the fields many attempts were made to destroy them by distributing wheat poisoned with phosphorus. These, however, were spasmodic and generally proved futile, as the fields experimented on were quickly reinvaded from adjoining lands. While a few fields favorably located were saved by early poisoning, the results of such unsystematic efforts amounted to practically nothing in overcoming or even materially checking the plague.

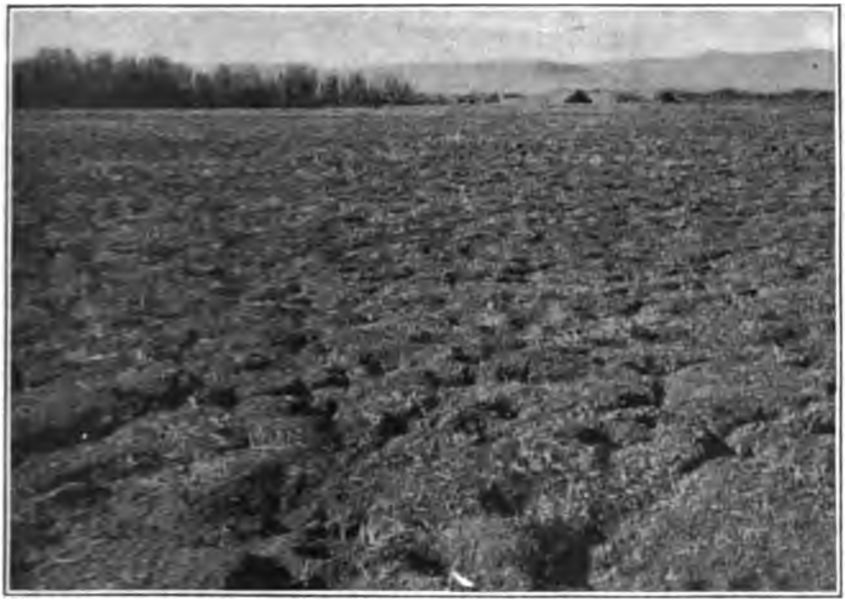

FIG. 2.—Alfalfa field ruined by mice, showing general condition of fields in Humboldt Valley in January, 1907.

The preparation in general use by ranchmen consisted of wheat treated with a strong solution of yellow phosphorus in carbon bisulphid, a cheap and effective poison for field mice, but inflammable, explosive, and dangerous to birds. As a result of its extensive employment in the valley, California quail, an introduced species, were decimated, and magpies, crows, meadow larks, and smaller seed-eating birds suffered extremely. On one occasion 67 horned larks were found dead on about 4 acres a few hours after the poisoned grain had been distributed. Fortunately hawks, owls, gulls, and ravens were not affected, but many skunks and domestic cats were killed as the result of eating mice dying or dead of phosphorus. Several accidents occurred in handling the solution, and cases of fatal poisoning of live stock were frequent.

Several attempts by ranchmen to induce contagious diseases among the mice by means of advertised bacterial preparations failed.

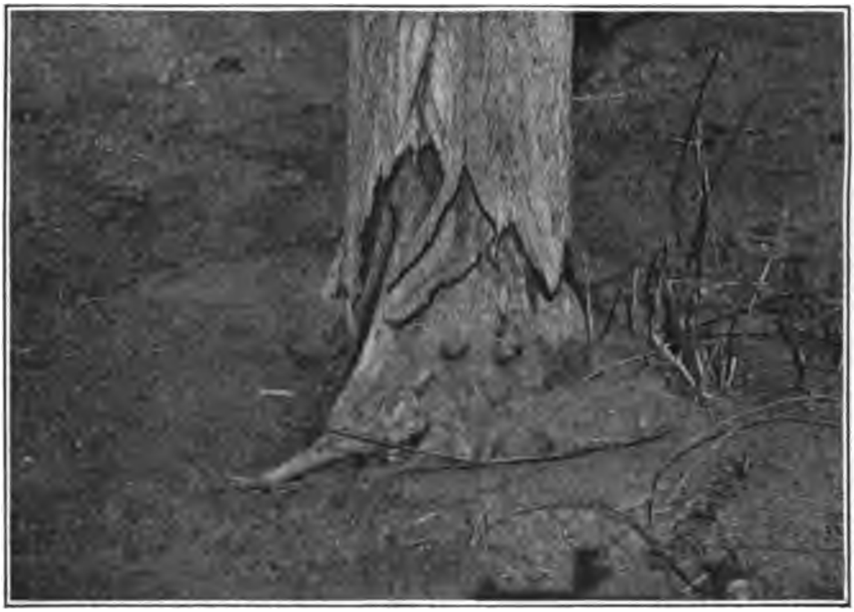

FIG. 3.—Lombardy poplar girdled and killed by field mice.

HOW THE OUTBREAK WAS FINALLY CONTROLLED.

Chiefly through the cooperation of Mr. George S. Webb, manager of the large Rodgers ranch, systematic experiments to destroy the pests, undertaken early in January by the Biological Survey, yielded results demonstrating that such mouse plagues can be controlled, and the greater part of the losses prevented. The experiments proved that mice could be effectively destroyed in winter by alfalfa hay poisoned with strychnia sulphate, and this preparation was generally recommended in the valley. On the Rodgers and Anker ranches a force of 7 to 15 men was employed to distribute the poison in the fields, with most satisfactory results, and without the dangers incident to the use of phosphorus and grain.

During this winter season, when the mice were not breeding, large numbers of predatory birds and mammals had steadily depleted their numbers. Mortality, believed to be due to disease, perhaps engendered by the straitened food supply and the severe winter weather, had been everywhere evident. Dead and dying mice attracted general notice, and in opening burrows where no poison had been distributed dead mice were frequently found in their nests.

By March 15, poisoning, supplemented by these natural agencies, had destroyed the mice on several thousands of acres where they were most abundant, and the plague was broken before the remaining alfalfa fields had been overrun. In scattered centers mice continued in destructive numbers until May, but without regaining to any considerable extent by reproduction, they steadily decreased. Later in the summer they had almost disappeared from the valley.

ESTIMATES OF DAMAGE.

The scourge of mice swept over about four-fifths of the cultivated area in the lower part of Humboldt Valley. Of about 20,000 acres in alfalfa, about 15,000 were so seriously injured as to require plowing and replanting. Over most of this area the alfalfa was replaced by grain crops for the season of 1908, at great expense and loss, since good alfalfa lands pay gross returns of from $60 to $70 per acre, while good grain crops return only $35 or $40 per acre.

The shortage of hay on the Rodgers ranch, where 2,200 acres were in alfalfa, was estimated at 2,000 tons. On Anker's ranch of 650 acres, it was estimated at 600 tons. Other ranches suffered in proportion, and the loss of hay in the valley amounted to not less than $50,000. The following estimates, independently considered, indicate the severity of the depredations. W. C. Pitt, who farms 1,400 acres of alfalfa, estimates his complete loss at $20 per acre, or $28,000. John Font estimates his damage on 1,000 acres at $20,000, and Mr. Anker considers his loss on 650 acres to be $8,000. Mr. Webb, on the Rodgers ranch, figures the complete loss on 2,200 acres, part of which pays considerably short of the best returns, at $30,500.

A careful consideration of the losses in hay, pasturage, root crops, and trees, the expense of restoring alfalfa fields to their former condition, and deducting the value of a grain crop for 1908 shows the average loss to be about $20 per acre.[a] On this basis the damage to the valley amounts to $300,000. Allowing for the saving of a few fields by early poisoning, and for others not entirely destroyed, the loss may have been a little less than $300,000.

Simultaneously with the plague in the lower part of Humboldt Valley mice appeared in enormous numbers farther up the Humboldt

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[a] Figured on the basis of 1,000 acres on Rodgers ranch.

River and its tributaries about Winnemucca, Battle Mountain, and in Paradise and Little Humboldt valleys. As the lands infested in those districts were chiefly great natural hay meadows of red top and wild clover, the damage was less severe. However, gardens and isolated alfalfa fields were seriously injured. Later, reports of mice in alarming abundance were received from King River, Quinn River, and Carson and Smith valleys, Nevada; from Weber River Valley, and from Sanpete and Utah counties, Utah; and from Honey Lake Valley, California. In none of these localities was the damage so extensive as in Humboldt Valley, though plagues of like severity were plainly threatened.

A PLAGUE THREATENED IN CARSON VALLEY.

Reports of severe damage by mice in Carson Valley, a hundred miles southwest of Lovelocks, in April, 1908, led to investigations which have an important bearing on the subject. Carson and Humboldt valleys are alike in having large areas in alfalfa bordered by desert lands on which field mice do not live. On a tract of about 2,500 acres near Minden, mice were found to be excessively abundant, and in some fields 10 to 25 per cent of the alfalfa plants had already been destroyed. Several smaller centers were similarly affected, while over the valley generally the mice were somewhat in excess of normal numbers. This was a condition similar to that presented in Humboldt Valley during the spring of 1907, and young of all sizes were abundant. Examination of many females, a large percentage of which were pregnant, showed an average of from 6 to 7 young, while in a number as many as 10 were found. Many females suckling young were found to be again pregnant. This was in marked contrast with the condition in Humboldt Valley, where, at this time, the mice were steadily decreasing without any general reproduction. The mortality among the mice so strongly in evidence during the winter and spring in Humboldt Valley was not found here. In fact, the pests were plainly increasing; while in Humboldt Valley they were steadily diminishing. Reproduction at the rate noted at Minden might and probably would have resulted in a plague by fall.

It can not be too strongly emphasized that at this stage of development mouse plagues can be checked, as was demonstrated by results actually obtained here. Although alfalfa was already well grown, furnishing the mice abundant food, by systematic poisoning they were so effectively reduced in the infested areas as not to be dangerous again during the season—in other words, a plague was averted.

PREVIOUS OUTBREAKS.

This is not the first time that field mice have inflicted serious damage in Humboldt Valley. Accounts by the older ranchmen indicate that a similar scourge occurred from 1889 to 1892. The mice were very abundant during the period from 1899 to 1901, the outbreak approaching in severity the present one, though affecting less of the valley. Between these periods damage of more local nature was frequent. The same species was reported to be extremely abundant and very injurious to crops in Carson Valley in 1892,[a] and several times since it has seriously menaced the valley.

ORIGIN AND PROGRESS OF SUCH PLAGUES.

A few observations on the development of this mouse plague are pertinent, since they bear directly upon the control or prevention of similar irruptions in the future. Always present in Humboldt Valley, these mice attract little attention when in small numbers. Usually they are not uniformly abundant in the district; in fact in many of the fields they may not be present at all. They live in scattered colonies in swampy places; along the borders of sloughs and irrigation ditches; in salt grass patches and in similar damp areas. When in normal numbers a little damage may be noticeable about the borders of fields or along ditches, where plants have been killed during winter and spring. Ordinarily the mice are very prolific, each pair producing 4 to 6 litters of about 6 young each during the long breeding season, which extends from March to November; and probably the young born early in the season breed before fall. Occasionally conditions favor excessive multiplication, and under such circumstances damage soon becomes evident, and in a single season may increase locally to the serious injury of fields. Extending from such centers during the next breeding season, and increasing not only by reproduction but by joining with other colonies, a vast army of mice is formed. Because of overcrowding and the limitation of food, such armies invade adjoining districts, and this progress becomes more rapid with the disappearance of green food in the fall. Through the combination of several such armies, entire districts are overrun.

Mice plagues usually develop within the affected districts. The essential point is this: It takes several seasons to produce a general plague of mice, and damage is noticeable for at least a season before a serious outbreak occurs. Though natural agencies may be depended upon to overcome such abnormal numbers finally; yet, unless active repressive measures are taken, enormous damage to crops will result. Control, easy at first, becomes more and more difficult as the mice increase in numbers, and, after a plague is well established, is very expensive.

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[a] W. W. Price, Zoe. Vol. 4, 1893–4.

THE SPECIES RESPONSIBLE FOR THE PLAGUE.

The mouse which produced the plague in Nevada, locally known as "black mouse" (fig. 4), proved to be the Carson field mouse (*Microtus montanus*), one of the numerous species of short-tailed field mice or meadow mice, a group which has caused widespread destruction in various parts of the world.[a] This field mouse is rather widely distributed in the valleys of Utah, Nevada, northeastern California, and eastern Oregon. In nearly all parts of the United States short-tailed field mice are among the most abundant of mammals, and a number of species in widely separated localities have occasionally exhibited the same tendency to excessive increase, indicating that favoring conditions may produce mouse plagues wherever the mice exist. Even when in small numbers they destroy considerable clover and alfalfa and injure orchards, nurseries, and root crops.

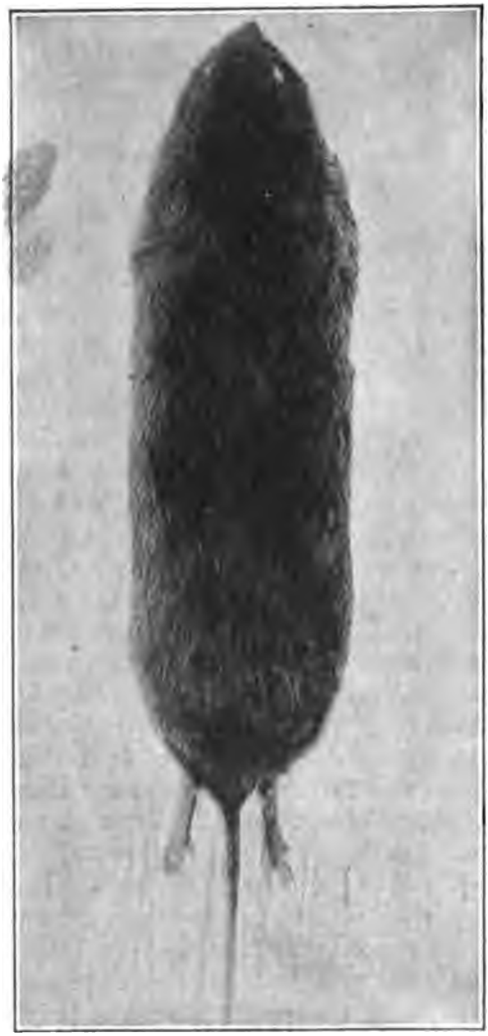

FIG. 4.—The Carson field mouse (*Microtus montanus*).

This is the first recorded instance of an irruption of field mice in North America attaining the proportions of a plague. The experience indicates the probability of future and even more disastrous outbreaks. In the extensive reclaimed areas of the West the abundant food and luxurious cover furnished by alfalfa fields and the miles of irrigation ditches, which afford these mice suitable homes along their banks, greatly favor their increase, while surrounding desert conditions limit the spread of mice beyond the cultivated areas.

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[a] For an account of the group see Bulletin 31, Biological Survey.

REPRESSIVE MEASURES.

POISONS.

Without doubt poisoning is the best method at present known of dealing with field mice on an extensive scale. Besides effectiveness, poisons should possess the additional advantage of small cost and the least possible danger to man, to domestic stock, and to valuable wild birds and animals. Comparative tests of a large number of poisons, including strychnine, phosphorus, lead acetate, mercuric chloride, arsenic and its compounds, proved strychnia sulphate by far the best and most practicable. Used in proper proportions it is no more costly than arsenic, lead acetate, or mercuric chloride. Moreover, it is much more readily eaten than are these poisons, which render some of the best baits unattractive to mice. Used on wheat it is considerably more expensive than phosphorus, but possesses many advantages; however, it may be used on mediums which make it the cheapest poison practicable.

Phosphorus.—Yellow phosphorus is exceedingly dangerous to handle and sometimes causes disastrous fires. Its solution in carbon bisulphid is highly explosive, while wheat grains poisoned with it are eaten readily by many birds. Thus the wheat poisoned with this solution, used by many Nevada ranchmen, was as dangerous a poison to prepare and to use as could well be devised. The preparation was in the form of a rapidly diffusing liquid, of which six ounces were sufficient to poison a sack of wheat.

Many ranchmen adopted the method of broadcasting the poisoned wheat over their fields, either by means of broadcast seeders or by hand. About 40 pounds of grain were required for each acre. Though many mice were killed, this method falls far short of yielding the best results. It is not much cheaper than other methods, as the proportion of poisoned grain wasted makes up for the lessened labor. Furthermore, its use is attended with the greatest possible danger to birds.

A much better method of distributing this poisoned grain is to drop about half a teaspoonful into each mouse burrow. Field mice limit their movements to their own systems of trails and burrows, and it is essential to place a fatal dose of poison within reach of each mouse. About 90 per cent of the mice were killed by this method, but in the worst-infested fields a man could cover only three or four acres a day, and the average cost, including labor, was from 80 to 90 cents per acre.

Strychnine.—Strychnine is commonly on the market in two forms. For the purpose of poisoning field mice, care should be taken to procure strychnia sulphate, as this is much more readily soluble in water than ordinary strychnine crystals. Even in powdered form, the sulphate is required. It fluctuates considerably in price, but usually can be obtained wholesale at about 75 cents an ounce.

Poisons should always be prepared at a distance from the house, where stock and poultry are not endangered. To avoid danger to persons strychnine and the vessels in which it is used should, of course, be carefully handled and safely stored away when not in use. Ordinary 5-gallon oil cans, for which covers and wire handles have been provided, make excellent utensils. A firehole about 2 feet long and a foot wide, over which two iron rods are placed to support the cans, makes a fireplace where the solutions can be quickly prepared. Galvanized iron wash tubs are suitable for mixing the material if grain be used. For preparing poisoned alfalfa on the large scale usually necessary, a large metal receptacle which will permit the mixing of 30 pounds of hay at once is required. One or two oil cans marked into gallon measures, a sprinkling can, and several large strong spoons complete a handy outfit for preparing poisons.

BAITS FOR THE ADMINISTRATION OF POISON.

Tests with various baits or vehicles for poison show that three possess distinct advantages. These are alfalfa hay, green alfalfa, and crushed wheat.

Alfalfa hay.—Alfalfa hay was found to be the best vehicle or medium for carrying the poison in winter. It was used extensively in Humboldt Valley up to the time green food appeared in March. A single treatment of the fields destroyed from 85 to 95 per cent of the mice. Compared to the grain-phosphorus preparation it steadily gave as good or better results, and is about 30 per cent cheaper; furthermore, it is entirely without danger to birds.

Formula.

Chopped alfalfa hay	30 pounds.
Strychnia sulphate	1 ounce.
Water	5 or 6 gallons.[a]

The alfalfa hay should be fresh and green rather than bleached. Either chopped hay, including stems and leaves, or the fine material, chiefly leaves and blossoms from the bases of stacks, may be used. The chopped hay is preferable, since the stems retain the moisture longer. The hay should be chopped into about 2-inch lengths, an ordinary feed cutter being best for the purpose. The required quantity should be placed in a large metal receptacle, sprinkled with 3 gallons of fresh water, and well mixed with a pitchfork. Dissolve 1 ounce of strychnia sulphate in 2 or 3 gallons of water by heating in a closed vessel. Sprinkle the solution over the dampened hay and mix well until the moisture is all taken up. The hay may now be sacked and is ready for use.

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[a] Or as much as the hay will absorb.

Only enough of the material for immediate distribution should be prepared, as it deteriorates when kept for several days. It is best distributed by hand (fig. 5), placing a small pinch, equal to a teaspoonful, near the entrance of each burrow, and scattering a little here and there along the surface trails. Care should be taken to place the poison a little to one side of the mound (fig. 6) to prevent it from being covered by the earth thrown out. In cold weather, when the mice move about chiefly in their underground runs, it should be dropped *into the burrows*. The dampening of the hay freshens it remarkably and makes it a tempting substitute for green food. Many of the animals eating it die on the surface, but about 60 per cent of those destroyed die underground. The poison is effective for several days, and since much of it is carried into the burrows to be eaten later, its full effect is not at once evident.

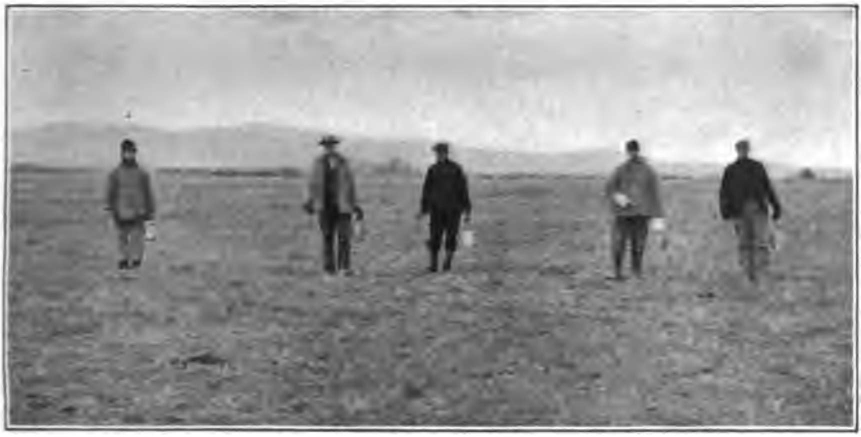

FIG. 5.—Men distributing poison.

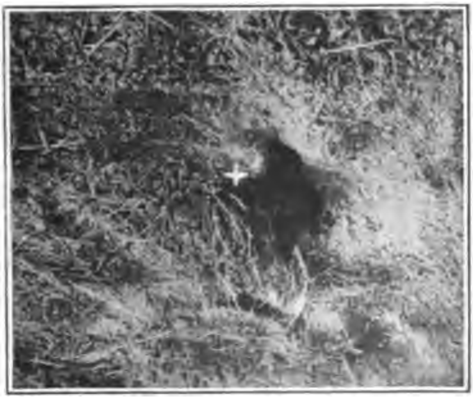

FIG. 6.—Where to place the poison.

Some farmers hesitate to distribute poisoned hay over their land for fear of poisoning stock. If properly done, however, there is practically no danger. The proportion of strychnine is small and calculated especially for mice. Rain or the irrigation of fields renders harmless any of the material left, and the small quantity it is necessary to put out soon shrivels to almost nothing from exposure to the sun. In Humboldt Valley extensive poisoning was not attended by a single accident. It is recommended, however, that stock be kept out of fields for a few days after poison has been distributed.

Green alfalfa.—In Carson Valley, in April, poisoning with green alfalfa hay was strikingly successful. Although the experiments in alfalfa fields were in places where green food was abundant, still nearly all the mice were killed in the areas treated (fig. 7). These animals habitually cut and store sections of alfalfa shoots during summer, and it is not surprising that the same material poisoned and placed in their runs should prove effective.

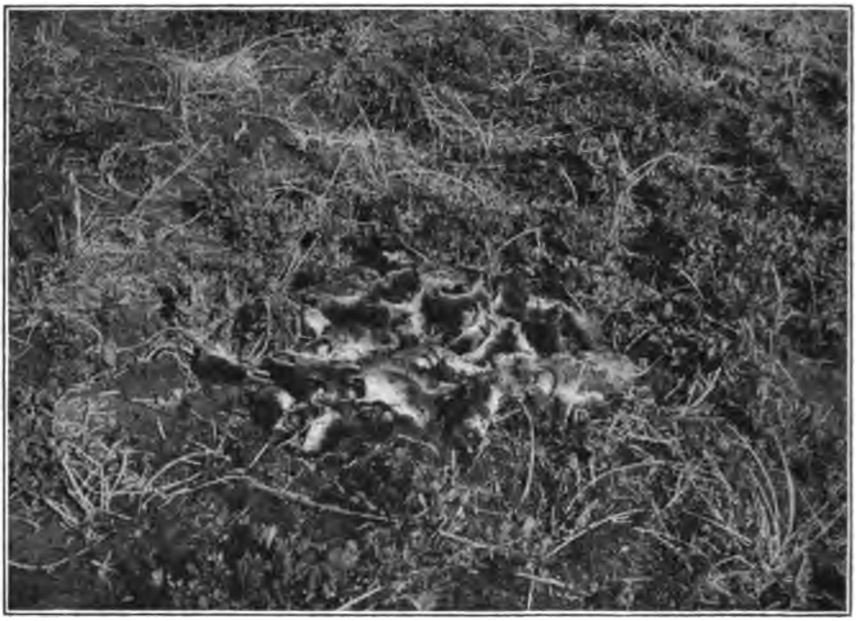

FIG. 7.—Field mice poisoned by green alfalfa.

Formula.

Green alfalfa	45 pounds.
Strychnia sulphate	1 ounce.
Water	1½ gallons.

Procure fresh green alfalfa, preferably young shoots, though leaves and tops of older plants also are good. Chop into lengths of 2 or 3 inches and place in a water-tight receptacle. Heat the strychnia in half a gallon of water in a closed vessel until thoroughly dissolved. Add the poisoned solution to one gallon of cold water and sprinkle it slowly over the alfalfa, mixing until the moisture is all taken up. In general the same method of distribution recommended for alfalfa hay should be followed. Several short pieces are sufficient for each burrow. Owing to the abundance of green food, greater care should be exercised in placing baits in the holes and along runways. As green alfalfa withers quickly when exposed to the sun, evening hours or cloudy days are best for its distribution. Though it can hardly be used extensively enough to suppress well-established plagues, it is recommended for small areas, or where mice are not excessively numerous. It is especially valuable for destroying mice along ditch banks or about the borders of fields during the irrigation of fields in summer.

Crushed wheat.—Crushed wheat possesses decided advantages over whole grain as a medium for poison. It is easier to prepare, and is more readily eaten, especially by young mice in summer. While considerably more costly than the phosphorus preparation, it is much less objectionable. The cost is not serious when mice are not extremely abundant over large areas, or when it is used to prevent plagues in the earlier stages.

Formula.

Crushed wheat	60 pounds.
Strychnia sulphate	1 ounce.
Water	2 gallons.

Heat the strychnia sulphate in the water in a closed vessel until completely dissolved. Sprinkle the solution over the wheat and mix well. Sweetening or scenting the preparation is unnecessary and even detrimental. When it is desirable to keep the poison several days, add two tablespoonfuls of powdered borax to prevent fermentation.

This preparation was used extensively in Carson Valley in April to check a plague of mice before alfalfa became too high to prevent effective poisoning. About 85 per cent of the mice were killed by a single treatment, and this was followed later by poisoning along the ditches and in other places where the animals persisted. The cost was about 40 cents per acre.

During these operations many blackbirds and magpies were poisoned. To a less extent meadow larks, killdeer, and mourning doves were destroyed. Though in this instance poisoned grain could not be replaced by less destructive preparations, it should, when possible, give place to poisoned green alfalfa. Winter poisoning with alfalfa hay will usually prevent the necessity for summer poisoning.

OBLITERATING BURROWS.

In the lands traversed by the scourge in Humboldt Valley, where over large areas mouse holes were scarcely a step apart, it was at once evident that there was great waste of material and labor in poisoning. Usually there were ten or more holes for each pair of mice, and in fields partially deserted the proportion of unoccupied holes was much greater. When all the holes were obliterated, the mice soon reopened those occupied, and poisoning could be done with the certainty of treating only the occupied burrows. A brush drag (fig. 8) proved best for the purpose. By this method a saving of about 40 per cent in labor and material resulted, and the average cost of destroying mice with alfalfa hay was reduced to about 35 cents per acre. While obliterating holes is practicable only under such extreme conditions as were presented in Humboldt Valley (fig. 9), it there proved of the greatest importance.

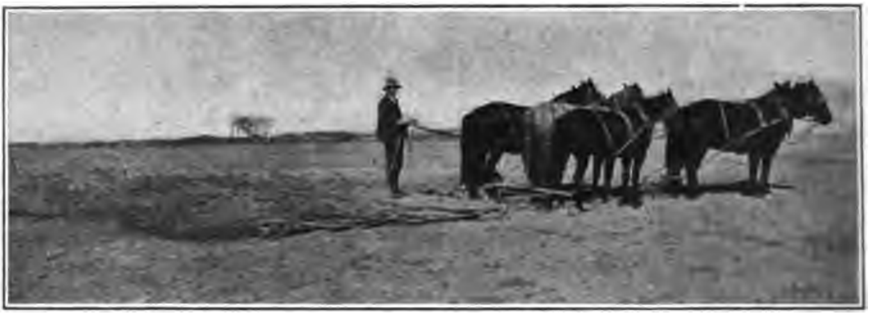

FIG. 8.—Brush drag used to obliterate mouse holes.

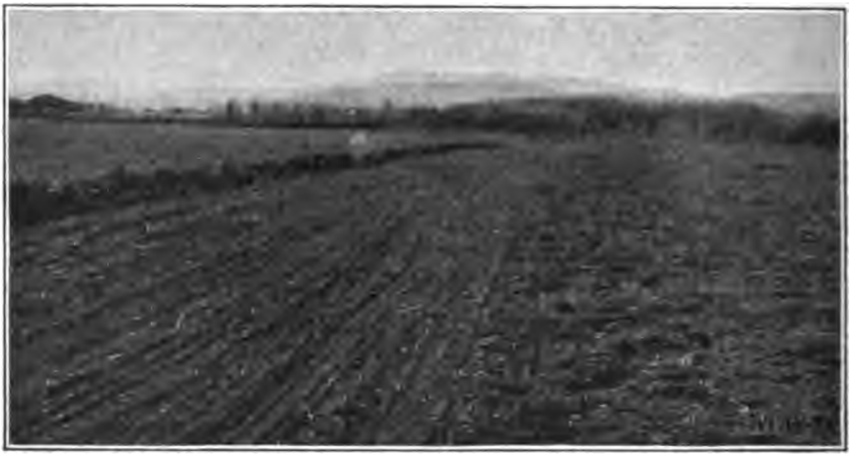

FIG. 9.—Effect of brush drag, showing mouse holes in part not dragged.

IRRIGATION.

Though irrigating in summer destroys a large percentage of the very young mice, it does not considerably reduce the number of adults. Moving ahead of the flood, they dart in and out of holes already full of water, swimming considerable distances through their underground tunnels. They cross ditches and furrows readily, traveling by water almost as easily as by land. Many take refuge in elevated spots and in straw or other litter in the fields, but by far the greater number are driven to the elevated ditch embankments and to the borders of fields. Within a few days after the water is withdrawn they again abound in the fields. Irrigation affords many opportunities for destroying the mice, both by poisoning and by dogs. It has also the effect of obliterating the burrows, so that for the next few days poisoning can be practiced with greater saving, since the occupied burrows are easily recognizable.

WINTER FLOODING.

It is said that flooding the fields in cold winter weather is an effective method of destroying mice, as when forced out of their burrows they soon perish from exposure, or are easily killed by dogs. This method has been successfully practiced in Carson Valley, and appears to be well worth trial. It can not be practiced in all irrigated districts, however, on account of the shortage of water at this season. It should be accompanied by poisoning along the ditch embankments and about the borders of fields.

BURNING.

In and about cultivated fields are many little areas where mice breed undisturbed. Waste strips along streams, swampy areas, and, on a larger scale, natural hay lands, serve as breeding places from which cultivated fields are invaded. Poisoning is not usually practicable in such places. Burning off the rank grass and weeds in winter or early spring is a great help in controlling field mice. Many of them perish, and the land is made uninhabitable for the survivors, driving them to locations where they may be more readily destroyed. In concerted attempts to control field mice, burning such areas should always precede poisoning operations.

DESTRUCTION OF WINTER COVER.

Very important in any attempt to control field mice is the keeping down of rank grass and other cover along ditches and about the borders of fields. The grass in such places is frequently left in haying time, because of the difficulty in cutting it. The last growth of alfalfa is often left to be killed by frost, when it should be pastured off or otherwise disposed of. Such cover affords the mice excellent protection from hawks, owls, and other predaceous birds.

PROTECTION OF TREES.

Clean cultivation is the greatest safeguard to trees. Where rank grass, weeds, or cover crops are allowed to remain under the trees in winter, the attack of field mice is invited. Damage to orchards is usually done under cover of weeds and snow and may reach serious proportions before being noticed. Many trees may be so badly injured that recovery is impossible, but most of them can usually be saved by promptly banking up earth about the trunks, entirely covering the wounded parts.

For protecting young trees thin wooden wrappers, called "tree protectors," are valuable. It is also highly probable that the lime and sulphur wash used by entomologists would prove effective. It should be applied at the beginning of winter.

DOGS AS MOUSE DESTROYERS.

Dogs are worth many times their keep when trained to hunt mice. Fox terriers or other small breeds take readily to hunting them and during irrigation and plowing destroy great numbers. Many farmers in Nevada keep dogs for the purpose of killing ground squirrels, pocket gophers, and field mice as they are forced out of their burrows by water, and in this way keep the pests in check. Plows turn out of the burrows practically all the field mice present, so that they become easy victims for dogs. Dogs trained to follow plows very materially reduce the number of mice in the areas covered. As an inexpensive and effective help in controlling field mice, dogs can not be too highly recommended.

SUMMARY OF REPRESSIVE MEASURES.

It has been proved that field mice are easily controlled by poisoning, or by a combination of poisoning and other methods, so there is little excuse for permitting mouse plagues to develop. Constant attention is obviously the way to avert such scourges. The encouragement of natural enemies, the destruction of rank cover, the keeping of well-trained dogs, and a little poisoning in winter, are ordinarily sufficient to hold the pests in check.

On account of its extremely dangerous character and the widespread destruction it causes, the use of phosphorus is not advised, especially since strychnia sulphate is fully as destructive to the mice at no greater cost. When mice are abundant in winter and early spring, thorough treatment with poisoned alfalfa hay will usually prevent serious damage in summer. When from neglect of this, or through other cause, it is necessary to destroy mice in summer, poisoned green alfalfa will commonly suffice. To avert threatened plagues at this season, where it is necessary to treat large areas quickly, poisoned crushed wheat is the best agent to employ.

NATURAL ENEMIES OF FIELD MICE.

Of the many remarkable features of the mouse plague in Humboldt Valley, none is of greater interest, or indeed, of greater significance, than the large numbers of birds and mammals which gathered to feed on the mice. In all other localities menaced these valuable allies of the farmer appeared in similar abundance. Under rows of trees, about the bases of fence posts, and scattered everywhere in the fields were regurgitated pellets of mouse fur and bones, affording abundant proof of the services rendered by birds; while many holes and destroyed nests in the fields showed the work done by skunks and coyotes. So apparent was the assistance rendered by these creatures that it attracted the attention and secured the protection of the farmers, many even sparing the coyote, whose services as a mouse destroyer deserve to be more widely recognized. In Nevada coyotes were frequently seen catching mice in the daytime, and their droppings were composed entirely of mouse fur and bones.

It is deplorable that, even when their usefulness is as apparent as here, some persons continue to destroy valuable birds and mammals. During the investigations in Humboldt Valley, no less than 29 large hawks were found hanging on wire fences, their useful lives ended by thoughtless gunners.

The striking evidence of the valuable services of the natural enemies of mice seen during this plague is but an example of their constant value. Hawks, owls, gulls, crows, ravens, herons, and shrikes among birds; and skunks, coyotes, foxes, weasels, badgers, and wildcats among mammals habitually prey upon field mice, and are most valuable in preventing undue increase of these pests.

Thorough studies have shown hawks and owls to be most beneficial allies of the farmer, orchardist, and nurseryman.[a] Most species rarely, and many of them never, attack poultry. But even were the depredations of the several species which kill poultry much more considerable, a small price would be paid for their services in destroying rodents. In the Nevada valleys all species of hawks and owls are distinctly beneficial, and here rigorous protection can not be too strongly advocated.

Among mammals the weasel and the skunk are especially worthy of protection. They are most persistent enemies of mice, and are less likely to be driven out by civilization than are other mammals. When particular individuals raid poultry houses it may be necessary to destroy them, though usually it is easy to make such houses proof against their attacks. Far from being a menace, they are generally most beneficial mammals, and living, are worth many times the value of their pelts.

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[a] See Circular No. 61 of the Biological Survey, Hawks and Owls from the Standpoint of the Farmer.

It is gratifying to note that in many localities the people are learning to appreciate these natural enemies of rodent pests, for even more important than legislation for the protection of valuable birds and animals is the recognition of their services by the farmers.

In Nevada it was noticed that hawks and owls hunted chiefly in fields near the few plantations of large trees to be found in the valleys. Beneath these trees the ground was fairly carpeted by disgorged pellets of fur and bones, representing thousands of mice. While certain species of hawks seldom frequent trees, others habitually perch in them, notably the large rough-leg, Swainson, and red-tail, which were the most abundant and persistent mousers. In nearly all of the valleys, even those which have been farmed for years, the absence of trees is notable. More trees along ditches, about the borders of fields, and in groves here and there would doubtless increase the number of valuable resident hawks and owls and attract more winter visitors.

CONCLUSIONS.

The plague of field mice in Nevada illustrates the dangerous proclivities of this group of rodents and stamps them as most serious pests. Since field mice possess in marked degree the tendency to periodic excessive multiplication, plagues are possible wherever they exist. In view of the natural increase of field mice resulting from the reclamation of desert lands and the gradual extirpation of their natural enemies, mouse plagues of vastly greater proportions are by no means improbable.

An understanding of the manner in which such plagues develop is essential in attempts to prevent them. Control, easy in the beginning, becomes very difficult and expensive after a plague is well established. In Humboldt Valley, in the beginning, a little poisoning with green alfalfa or crushed wheat would have sufficed to prevent the plague. During the fall and winter of 1906–7, when the mice seriously injured fields here and there, they could have been destroyed with poisoned alfalfa hay. Even during the summer of 1907 concerted and vigorous poisoning would have destroyed them at a cost small indeed in comparison with the damage they inflicted later.

Winter poisoning with alfalfa hay is the most practicable, since the absence of green herbage is a distinct advantage. Ordinarily, poisoning in winter will prevent the necessity for it in summer. When, however, mice appear in alarming numbers in spring they should be promptly suppressed, since under these conditions a plague may be well established by fall. But if in default of such preventive measures a plague is well established, nothing short of systematic and vigorous poisoning will check it. This requires the employment of enough men to cover the infested areas in a reasonably short time.

In localities where mice are present in destructive numbers, systematic effort to control them results not only in considerable saving to the ranchman, but proves the best safeguard against more serious damage.

On the enormous ranches of the West, the centers of abundance which form the starting points for general invasions may develop on the lands of persons who neglect to control them. If each ranchman will consider the suppression of field mice on his own land a regular part of farming operations, such scourges of mice will never occur.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 353.

Experiment Station Work,

L.

Compiled from the Publications of the Agricultural Experiment Stations.

COMMERCIAL CLOVER SEED.
DODDER IN ALFALFA SEED.
GROWING POTATOES UNDER STRAW.
HENS VERSUS INCUBATORS.
PREPARING FOWLS FOR MARKET.
PRESERVATION OF EGGS.
THE MOUND-BUILDING PRAIRIE ANT.
COAGULATION OF MILK IN CHEESE MAKING.
EFFECT OF ALKALI ON CEMENT STRUCTURES.
SILO CONSTRUCTION.
A CHEAP AND EFFICIENT STERILIZER
A CHEAP AND EFFICIENT ICE BOX.
THE POWER LAUNDRY FOR THE FARM.

JANUARY, 1909.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

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1909.

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[a] Director.

[b] Special agent in charge.

[c] Acting director.

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EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

CONTENTS OF NO. L.

Page.
Commercial clover seed.......... 5
Dodder in alfalfa seed.......... 7
Growing potatoes under straw.......... 9
Hens versus incubators.......... 10
Preparing fowls for market.......... 12
Preservation of eggs.......... 14
The mound-building prairie ant.......... 15
Effect of glass, metals, etc., on coagulation of milk in cheese making.......... 17
    Effect of rusty milk cans.......... 18
Effect of alkali on cement structures.......... 20
Silo construction.......... 22
    Failures of silos.......... 22
    Materials for silo construction.......... 24
    The appearance of the silo.......... 27
A cheap and efficient sterilizer.......... 27
A cheap and efficient ice box.......... 29
The power laundry for the farm.......... 31

ILLUSTRATIONS.

Page.
Fig. 1. Tools required for sifting alfalfa seed to remove dodder seed.......... 8
2. Hook used at Storrs Experiment Station to hold birds for plucking.... 13
3. Square cement silos connected with barn.......................... 17
4. A silo with redwood staves at the bottom; cheaper wood above....... 18
5. A large concrete silo which failed................................ 20
6. The patent roof of a silo, open.................................. 22
7. Method of making hoops and details of the construction of a stone and stave silo.. 23
8. Double wall brick silo... 24
9. Double wall concrete silo.. 25
10. Dairy barn and stock-judging building, erected in 1898............. 26
11. Brick silo, Iowa State College..................................... 27
12. A circular dairy barn with silo in center.......................... 28
13. Cross section of sterilizer.. 29
14. Cross section through ice box...................................... 30

EXPERIMENT STATION WORK.[a]

COMMERCIAL CLOVER SEED.[b]

Clean soil and clean seed are essential to a clean crop. These requirements are especially necessary when the crop to be grown is of slow development in its earlier stages, as in the case of clover, alfalfa, and certain other, particularly the grass, crops. When land has been kept free from weeds and the seed bed carefully prepared it is readily realized how great a loss results when noxious weed seeds are introduced with the seed for a crop. As is pointed out by a recent bulletin of the Connecticut Station, there is frequently great danger of securing in the open market clover seed of poor quality, and the advice is given that purchasers make sure of the quality of the seed before buying. Of fifty-one samples of clover seed examined by this station three were heavily adulterated with black medic and only ten were apparently free from dodder, and two of these had a very low vitality. Only one-sixth of the entire number of samples analyzed was fit for use.

With reference to the weight of the samples, it is said that clover seed of average quality should weigh about 1.5 grams per 1,000 seeds, making about 302,000 seeds to the pound. Of the samples examined twenty-six did not reach this standard. Two weighed only 1.27 grams or less, equal to 363,000 seeds to the pound, while on the other hand two weighed 2.92 grams per 1,000 seeds, equal to 236,000 seeds per pound. Sowing a certain number of pounds of light seed per acre would put a greater number of seeds on the area than if the same quantity of heavy seed was sown, but under the same conditions the heavy seed would be more likely to give a satisfactory stand.

The vitality tests made under laboratory conditions showed an average vitality of 86.6 per cent for the fifty-one samples, or, in other words, an average of 86.6 out of every 100 clover seeds in the germination tests had life enough to produce a sprout. This result is regarded as satisfactory, although the vitality is but little above the provisional minimum of 85 per cent recommended by the seed laboratory of this Department for commercial clover seed. Twenty of the samples fell below 85 per cent, four below 75 per cent, and the lowest was 64.2 per cent.

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Connecticut State Sta. Bul. 160. See also U. S. Dept. Agr., Farmers' Bul. 79, p. 17.

The purity of clover seed is likely to be of greater importance than its weight or its vitality. While light or old and weak seed may be the cause of a partial failure of the crop, and generally does result in an imperfect stand, impure seed often produces a greater loss by noxious weeds introduced with it, and especially is this the case if it contains dodder, which often partly or entirely ruins a crop and which may stay in the land as long as the particular clover crop is grown on it. The average purity in this collection of samples was 90.5 per cent, or 7.5 per cent lower than the provisional standard of this Department, which is 98 per cent. The expression "98 per cent purity" means that of 100 pounds of seed bought 98 pounds are clover and the rest is dirt or foreign seeds. A botanical analysis of five samples showed the presence of at least thirty-five species of foreign seeds, including several kinds of dodder and total numbers of foreign seeds ranging from 12,458 to 78,604 per pound. Attention is called to the fact that if the foreign clover, alfalfa, and timothy seeds present, which range from about 2,500 to 35,000 per pound, are left out of account a seeding of 8 pounds per acre of any of these samples would plant from two to eight weed seeds on every square foot of ground.

Three samples of the lot were evidently adulterated. The first contained 21.2 per cent, the second 22.6 per cent, and the third as high as 39.1 per cent of black medic (*Medicago lupulina*), a leguminous plant of little or no value and apparently chiefly used for adulteration of red clover seed, the importations of which into this country frequently carry a very high percentage of this adulterant. The two kinds of seed are of about the same size and do not differ much in color, although black medic seed never has the purple or violet color of red clover seed. The medic seeds are also more oval in shape than those of red clover, which have a distorted heart shape, a roughly triangular outline with rounded corners.

The weed most dangerous and destructive to the clover crop is dodder, and the seed of this pest is about as large as small clover seed and very difficult to separate from it. In color it is light gray, yellowish or light brown, dull, finely roughened, but not pitted. Its method of attacking the clover plant is described as follows:

> The seed of this weed germinates in the ground, sends up a thread-like stem, yellow or reddish in color, which immediately attaches itself to its host plant. If it finds no plant on which it can feed, it dies, being entirely a parasite. Finding a suitable plant, it twines closely around the stem or leaf, sends its sucking organs into the tissue, and lives on its juices, weakening or killing the host. Its connection with the ground

soon ceases, and when actively growing the stem may be cut into any number of pieces, each of which, if attached to clover, will continue to flourish. It flowers and produces abundant seed, which stocks the ground for the next clover crop. Clover infested with dodder lodges, mats together, can not be properly cured, and either because of the dodder present or the molding of the clover in consequence, has been known to scour cows when fed out as hay.

In twenty-eight carefully tested samples from 18 to 11,615 dodder seeds were found per pound of clover seed. It is pointed out that a seeding of 8 pounds per acre of these two samples would place one seed to every 300 square feet and two seeds to every square foot of land, respectively. From alfalfa seed the dodder seed may be separated by sifting in sieves made for this particular purpose, but owing to the small size of red clover seed this method can not be applied in cleaning it from dodder.

DODDER IN ALFALFA SEED.[a]

The appearance of dodder in clover and alfalfa fields is generally most dangerous to the crop. The ordinary operations of mowing, raking, and hauling tend to spread this troublesome parasite, and with every new center of infection the chances of the crop grow less. A recent circular of the New York Experiment Station at Geneva describes the injury resulting from dodder in alfalfa fields as follows:

> Dodder is a yellow, thread-like twining weed which is exceedingly troublesome in alfalfa fields. It appears in circular spots 3 to 30 feet or more in diameter. At the center of the spot the alfalfa is killed out, while around the margin the ground is covered with a mat of yellow threads which twine closely about the stems of the alfalfa plants and slowly strangle them. The spots increase in size from year to year. Many fields have been completely ruined by dodder. It is not often injurious to other crops (except red clover), but once established in an alfalfa field it is very difficult to eradicate without killing the alfalfa.

As dodder is usually introduced with clover and alfalfa seed, the purchase and use of dodder-free seed can not be too strongly urged. Clean seed, however, can not always be secured, and therefore cleaning the seed is often necessary. Frequently neither the purchaser nor the seed dealer knows dodder seed, and consequently in many cases the first proof of its introduction is the appearance in the field of the weed itself. In view of these facts, the New York Station recommends that seed be examined before it is sown to determine the presence of dodder.

Alfalfa seed is larger than dodder seed and advantage was taken of this fact by the station to perfect a method by which commercial alfalfa seed may be made practically free from dodder and safe to sow. It was found that dodder seeds are readily removed by sifting through a wire sieve having 20 meshes to the inch. Since ready-made sieves of this mesh are not readily obtainable, it is advised to construct a light, wooden frame 12 inches square by 3 inches deep and tack over the bottom of it 20 by 20 mesh steel-wire cloth of No. 34 Washburn & Moen gauge wire. (Fig. 1.) This quantity of wire cloth ought not to cost more than 15 or 20 cents. In case brass or copper wire cloth is used the wire should be No. 32 on the English gauge. It is important that the wire cloth used be exactly 20 by 20 mesh, which may be determined by placing a ruler on the sieve or cloth and counting the number of spaces to the inch. With a sieve of this kind it is estimated that a man can clean from 3 to 7 bushels of alfalfa seed per day. From one-fourth to one-half pound of seed, and no more, should be put into the sieve at a time and vigorously shaken for one-half minute. To make the work uniformly thorough the use of a cup holding not over one-half pound of seed and careful timing of the sifting is recommended. If the seed contains but little dodder one sifting may do, but when much dodder is present, and particularly if it is of the large-seeded kind, two siftings, both made strictly as directed, are advised.

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[a] Compiled from N. Y. State Sta. Circ. 8.

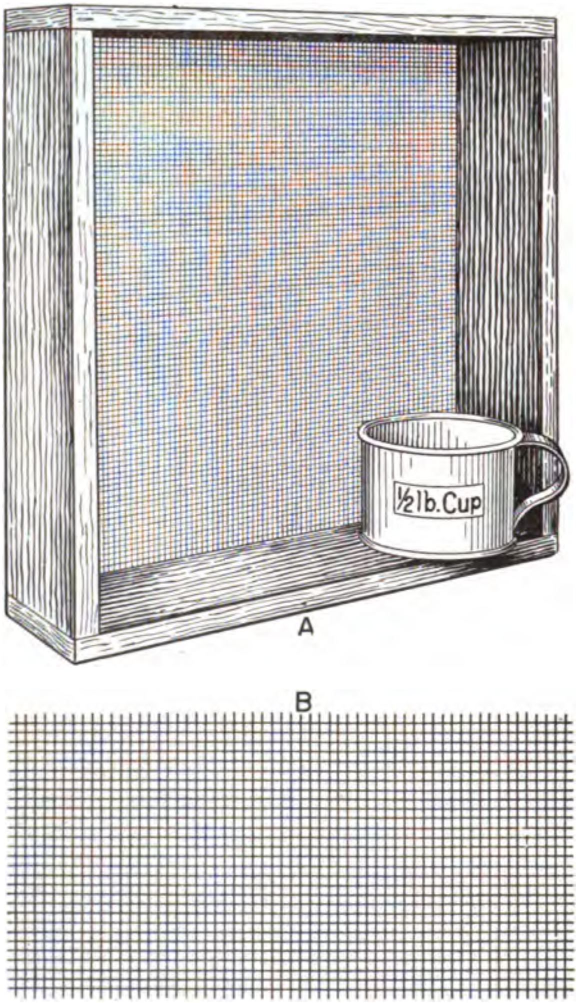

FIG. 1.—Tools required for sifting alfalfa seed to remove dodder seed: A, Home-made sieve 12 inches square by 3 inches deep; B, 20 by 20 mesh wire cloth made of No. 34 steel wire. (Natural size.)

In experimenting with this method it was observed that besides the dodder seeds various other small weed seeds, broken seeds, and dirt, as well as some of the smaller alfalfa seeds, were also removed by sifting. The siftings varied from about 1 to 5 pounds per bushel, according to the original cleanness of the seed and the thoroughness of the sifting. The rejection of the siftings is considered as causing but little if any loss.

GROWING POTATOES UNDER STRAW.[a]

In a previous bulletin of this series[b] attention was called to the good results obtained by R. A. Emerson, of the Nebraska Station, in growing seed potatoes under mulch. Seed so grown was found to be, under the warm dry summer conditions of Nebraska, much better than that produced by ordinary methods of culture. Mulching was also found as a rule to increase the yield, and the results in general indicate that while mulching would not be practical on a large scale, on account of the large amount of mulching material needed and the cost of application, it is entirely feasible on a small scale, as for instance, when the farmer raises a few potatoes for his own table or when he wishes to raise a few seed potatoes.

The practice has much to commend it in hot, dry climates, as the mulch conserves the soil moisture, but is not so successful in a wet season unless the ground selected is well drained. Another reason for the use of mulches is that it saves cultivation in the busy season, and in this respect early mulching is preferable to late mulching.

A writer in The Agricultural Gazette, of New South Wales, says:

> Perhaps no other field or garden crop is more benefited by a liberal mulch of wheat straw (or other litter) than potatoes, and especially is this the case with the second crop planted, say, in January. If the soil be well fined, the potatoes planted closely and covered shallow, and a mulch of from 1 to 3 or 4, or even 6 inches of straw applied immediately upon planting, good results are sure to follow. The potatoes will need no cultivation if the straw be applied at once before a packing rain. It prevents the packing of the soil by such a rain, breaking the force of the descending drops, and letting them down to seep slowly into the soil; and, intervening between soil and wind and sun, keeps it there, very largely, at least. It would be [a very] bad year if potatoes failed to do well under such treatment.
>
> If every farmer who grows wheat will try the following plan he will, in a figurative sense, convert his wheat straw into potatoes: As soon as the stripper has harvested the grain, mow the straw with mowing machine or scythe and rake into windrows, with horse rake or otherwise. Immediately plow and harrow the land between the windrows, and plant the potatoes in the usual way, only they may be planted in rows closer together than the usual distance, in order to economize the mulch. Plant in shallow furrows, and cover with the harrow, leaving the land perfectly level. Cover at once with the mulch of straw to whatever thickness you have straw sufficient for, and the work is done. The potatoes will come up through the straw and flourish, and never be troubled by weeds. No further cultivation will be necessary. When the potatoes are gathered, many fine tubers will be found, not only in the soil and near the surface, but lying on the top of the ground just under the straw. * * *

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[a] Compiled from Nebraska Sta. Bul. 97; Agr. Gaz. N. S. Wales, 11 (1900), No. 1, pp. 46, 47; 19 (1908), No. 3, p. 104.

[b] U. S. Dept. Agr., Farmers' Bul. 305, p. 8.

If wheat straw is not available for mulching potatoes, bushes, suckers, and green branches from trees laid thickly over the whole surface of the soil will be found a very good substitute.

It is to be noticed that the above was written for a country that is subject to periods of drought; also that January there corresponds to July in this hemisphere.

Another writer in the same journal describes an extreme type of the mulch method of growing potatoes, which may be used on heavy stiff lands not suited to potatoes, as follows:

> The ground is plowed deeply and harrowed into a good state of tilth; the potatoes are then placed by hand firmly in the soil until they are about half covered; then 12 to 15 inches of wheaten straw is placed over them; this completes the planting. Nothing more is done until the potatoes are picked—not dug—from under the straw, for they lie on top of the ground around the seed set. * * * The straw forms a protection from the sun and other destructive agents, the same as the earth does when they are grown in the ordinary way.

This method of course commends itself only for small scale garden operations, but certainly has the advantages of ease and simplicity. Potatoes so grown can be easily removed from the hill from time to time as they mature.

A method of this kind has been used to some extent in certain parts of this country, where it is known as the "lazy bed." While convenient and economical of labor, it of course is not to be recommended except where better methods of culture are not feasible.

HENS VERSUS INCUBATORS.[a]

The question of the relative merits of hens and incubators as a means of hatching chickens is of much importance to all who raise poultry on a scale at all extensive.

The person who raises only a small number of chickens will, as a rule, do better to use hens for hatching purposes, while the commercial poultryman, who must be able to have stock ready for market at different times, is practically compelled to use incubators. However, all studies of the relative efficiency of the two methods of hatching are of value since they may point the way for improvement in the artificial method of incubation, bringing it gradually nearer in results to the natural method.

The Oregon Station has recently made studies of various problems of incubation, and the results bearing on relative efficiency of hens and incubators are summarized as follows:

(1) From 879 eggs set, incubators hatched 533 chicks, or 60.6 per cent.

(2) From 279 eggs, hens hatched 219 chicks, or 78.8 per cent.

(3) Eliminating eggs broken in nests, the hens hatched 88.2 per cent of eggs set.

(4) The incubators hatched 78.5 per cent of "fertile" eggs, and the hens hatched 96.5 per cent.

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[a] Compiled from Oregon Sta. Bul. 100.

(5) Eggs incubated artificially tested out 22.7 per cent as infertile, while those incubated by hens tested out 11.8 per cent.

(6) The incubators showed 16.6 per cent of chicks "dead in the shell," and the hens 2.8 per cent.

(7) Chicks hatched under hens weighed heavier than chicks hatched in incubators.

(8) The mortality of hen-hatched chicks brooded in brooders was 10.8 per cent in four weeks, and of incubator-hatched chicks 33.5 per cent.

(9) The mortality in hen-hatched chicks brooded under hens was 2.2 per cent, and of incubator chicks 49.2 per cent.

(10) In other tests the mortality was 46.5 per cent for incubator chicks brooded by hens and 58.4 brooded in brooders.

(11) Hen-hatched chicks made greater gain in weight than incubator chicks, whether brooded by hens or brooders.

From these results Professor Dryden concludes that hens were more efficient hatchers than the incubators, though the incubators hatched a fairly satisfactory number of the eggs.

It may be true in practice that the incubator will hatch as many chicks, on the average, as the sitting hen, because the hen sometimes breaks eggs in the nest and sometimes quits her job, two things that the incubator is not guilty of, though occasionally the lamp will go out, the temperature will go wrong, and all the eggs will be spoiled. But this is a matter of care with the operator, and with fair care the loss from accidents will be less in the incubators than under hens. It may therefore be that an incubator properly attended will, on the average, hatch as many chicks from a certain number of eggs as a certain number of hens will hatch from the same number of eggs of the same kind.

Successful incubation, however, does not mean merely the hatching of a large percentage or a certain percentage of the eggs; the serious problem is not how to hatch the greatest percentage of the eggs, but it is rather how to hatch the largest number of chicks of greatest vitality. The test of the incubator is not that it hatch, on the average, as large a percentage of the eggs as the sitting hen, but that it hatch as many and as good chicks as a good sitting hen. Until this can be done poultry enterprises will continue to lag where artificial methods of incubation are used.

On the whole the results show that artificial incubation is responsible for the large percentage of chicks "dead in the shell," as well as for the large mortality of chicks in the brooder. There are doubtless brooder problems affecting the vitality of the chick, but this fact should not obscure the plain demerits of artificial incubation. * * *

That the incubator is the cause of the mortality in the chicks was demonstrated in two ways: First, when hen-hatched chicks and incubator-hatched chicks were put together in the same brooder, the former lived well and the latter showed a large death rate; and, second, it was demonstrated when hen-hatched chicks and incubator-hatched chicks were put together with the same hen or hens, the former lived well and the latter showed the usual mortality, or practically so.

In considering the relative profitableness of the two methods, account should also be taken of the relative cost of labor.

The figures given above show that there was a marked difference in weight of hen-hatched and incubator-hatched chicks. While the cause of this difference was not definitely determined in these experiments, it was found that the adding of moisture to the incubators increased the weight of the chick. Professor Dryden is of the opinion, however, that it is not a question of moisture alone, because he found "that by increasing the moisture in incubators to such an extent that the eggs lost less weight than eggs under hens normally, the incubator chicks weighed less than the hen chicks, though the moisture increased the weight of the incubator chicks."

The proper handling of incubators is fully discussed in a Farmers' Bulletin of this Department.[a]

PREPARING FOWLS FOR MARKET.[b]

In continuation of his suggestions to amateur poultrymen previously noted,[c] C. K. Graham in a recent bulletin of the Connecticut Storrs Station gives directions for preparing fowls for the market. He states that "the method of killing not only affects the plucking of the fowl, but will to a large degree affect the quality of the flesh."

Chickens should not be chased or excited before killing, as this is thought to have an unfavorable effect on the flavor and texture of the flesh. To avoid this it is well to have a catching hook such as is described in a former bulletin of this series.[d] The best method of killing is probably by bleeding, and is described as follows:

> Hold the head of the bird with the left hand, back of the head up, keeping the hand on the back of the neck to avoid cutting yourself should the knife slip and pass through the top of the head. Take the knife in the right hand, the back of the blade toward your body. Insert the blade in the mouth, keeping the point to the right side of the bird's neck and as near the outer skin as possible until it is well past the neck bone. Then press the edge toward the bone and slowly draw the knife from the mouth, the hand moving from your body, so that the knife appears to pass across the neck. Repeat the process on the left side of the neck. This should cause the bird to bleed freely, but by holding the beak up the blood will remain in the neck, giving you plenty of time to pierce the brain. The latter is located just above the eye and can be easily reached through the upper part of the mouth by using a stiff steel blade, inserted in the mouth with blade edge up and pointing slightly over the eye. With young birds little trouble is experienced in piercing the brain, but with older birds a very stiff blade is required, as the bones are much harder. When the point of the blade enters the brain, give the knife a quick twist to right or left to widen the aperture. If the brain has been reached, the bird will attempt to squawk or will give a nervous jerk as the blade touches the spot, and this touching the brain or nerves not only loosens the feathers of the bird for dry plucking, but will greatly improve the appearance of scalded stock.

A weight, which may consist of an old tomato can half filled with stones and cement, is immediately attached by means of a wire hook to the lower mandible of the bird. "Then by grasping the wings close to the back, the bird will not be able to flutter, and can be easily and rapidly plucked. This, of course, should always be done while the bird is bleeding. * * * The can catches the blood, and by hanging the bird over a barrel the feathers may easily be saved."

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[a] U. S. Dept. Agr., Farmers' Bul. 236.

[b] Compiled from Connecticut Storrs Sta. Bul. 52.

[c] U. S. Dept. Agr., Farmers' Bul. 237, p. 22.

[d] U. S. Dept. Agr., Farmers' Bul. 317, p. 31.

Since there is considerable difficulty in scalding birds properly and it is often improperly done, dealers usually pay a little more for dry-plucked birds.

The breast should be plucked first, starting near the crop. After the breast the thighs, then the back near the base of the tail, and last the wings. As soon as the feathers have been removed the wings should be twisted over the back and the bird taken from the hooks and the feet washed, after which the thighs and legs should be pressed to the body either by placing a brick on the bird's breast or by tying the body, the object of this being to give the bird a plump or blocky appearance.

The birds should not be allowed to hang until they become rigid, as that causes them to look thin. Care must be taken that all animal heat has left the birds before they are packed for shipment, but this does not mean that it is necessary for them to hang while cooling.

As a rule, the head and feet are left on and the entrails are not removed, but such details depend on the requirements of the market to which the birds are sent. The following directions are given for preparing drawn poultry:

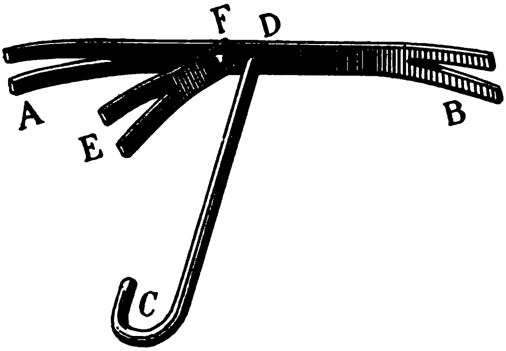

FIG. 2.—Hook used at Storrs Experiment Station to hold birds for plucking: A-B, bar; C-D, staff; E-F, arm.

Broilers.—Lay the bird on its side, draw the knife down the back, beginning between the shoulders near the neck, and cut through the backbone or along each side and remove the bone. Continue cutting past the oil sack and tail around to the end of the breastbone, then lay the bird on its breast. The entrails can then be easily removed, and the blood, if any, wiped out with a dry cloth.

Roasters.—Place the bird on its breast, head down. Inserting the point of the knife in the back just between the shoulder blades, continue the cut along the back of the neck to the head. Near where the blade first cut the skin will be noticed a white spot, which marks the joining of the neck to the backbone. By a little manipulation with the point of the blade the neck bone can be easily severed at this point. The aesophagus and wind pipe should then be separated from the skin of the neck, after which the head may be removed, making the separation from the skin of the neck as near the head as possible. The crop is then easily removed, and after being severed from the entrails, the latter, including the lungs, should be loosened from the frame of the bird by inserting the finger in this opening. The bird should then be placed with the vent up. Hold the vent with the left hand and cut around it, and in doing so loosen the main gut from the back of the fowl. In this way the entrails can be removed with little or no dirt, and through a very small opening.

Many consumers object to a roasted fowl on which the flesh has been drawn off the bones at the knee joints. This can be overcome by leaving a little of the yellow scale or shank on the back of the leg at the knee when removing the shanks.

All birds intended for roasting should have the sinews of the leg removed. To do this cut the skin of the shank lengthwise just back of the bone. With an eight-inch screw-driver raise the sinews, and by a twist of the tool these may be parted. They can then be pulled easily by holding the leg and screw-driver as you would a bottle and corkscrew.

A convenient hook for holding fowls for plucking is shown in figure 2. The bar A–B is of quarter-inch iron 1 inch wide and 18 inches long, with a split 3 inches long and about three-fourths of an inch wide at each end. A 5-inch arm E–F is riveted to A–B 1½ inches from D, making the distance from B to E about 15 inches and providing for fowls too small to spread from A to B. The staff C–D is of half-inch round iron 18 inches long with a shoulder at D and riveted on the under side of A–B, so that the latter will swing freely.

PRESERVATION OF EGGS.[a]

The best means of preserving eggs, particularly methods in which water glass is used, have been discussed in several earlier bulletins of this series,[b] and much has been written on this subject, but the question of securing eggs in the best possible condition for preservation has heretofore received little attention. G. H. Lamson, jr., of the Storrs Experiment Station, has, however, recently reported investigations on the causes and sources of infection which may result in the spoiling of eggs and on the best practical means of securing clean, sound eggs for preservation in water glass.

It was found that eggs may be infected with the bacteria of decay in the oviduct before the egg is laid, and through pores and defects in the shell after the egg is laid. Much can be done to reduce the chances of infection and to reduce or prevent the injurious effects of infection, thereby greatly improving the keeping quality of the eggs. In the first place the hens should be kept in as nearly perfect health as possible and should be given enough shell-forming food to enable them to make strong shells of uniform thickness.[c] Clean nesting places are necessary to prevent infection in the nest. The eggs should be gathered daily and kept in a dry, cool room or cellar where the sun's rays do not fall directly upon them. Only clean eggs should be used for preservation and these should be placed in the preservative within twenty-four hours after they are laid.

Eggs laid during April, May, and early June were found to keep better than those laid at any other season. It is recommended, therefore, that only eggs laid at this season be preserved. It was found that water glass when properly made seals the eggs to prevent further infection and when kept at a comparatively low temperature prevents the multiplication of bacteria (decay) within the egg. Water glass can usually be obtained through druggists at from $1 to $1.25 per gallon, a gallon of the water glass being made into 10 gallons of preservative by simply dissolving it in 9 gallons of water which has been boiled and cooled before use.

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[a] Compiled from Connecticut Storrs Sta. Bul. 55.

[b] U. S. Dept. Agr., Farmers' Bul. 296, p. 29.

[c] U. S. Dept. Agr., Farmers' Buls. 186, p. 26; 225, p. 26.

The preserved eggs should be kept in a cellar or room of even temperature which does not go over 60° F.

If care is taken to select clean, sound eggs, and proper precautions are observed in carrying out the details of the method of preservation as above indicated, it is believed that water glass furnishes a cheap, reliable, and easily employed preservative for domestic use, "and by its use everyone having a supply of fresh eggs in the spring can make a considerable saving, and at the same time have a larger number of fresh eggs to use in the winter."

THE MOUND-BUILDING PRAIRIE ANT.[a]

In a recent bulletin of the Kansas Station, T. J. Headlee and G. A. Dean describe the prairie ant and the mounds they build and discuss their economic importance from an agricultural standpoint. It is shown that "while it is true that they destroy a small percentage of cultivated crops, their substantial claim to the title of injurious insects lies in the annoyance caused the farmer in cultivating and harvesting his crops and in the discomfort resulting from their efforts to protect their habitations when occupying public streets, sidewalks, much-used paths, dooryards, and corrals."

The ant mounds are found throughout western Kansas and the neighboring States, comprising the Western plains. They are sometimes circular, but usually elliptical at the base, and are from 2 to 6 feet in diameter and vary in height from a few inches to as much as 2 feet. The ants clear a circular space around their mounds, removing all vegetation from it to a distance of 5 to 10 feet from the mound on all sides; the mound is usually exactly in the center of the cleared space. The outside of the mounds is covered with gravel or other coarse material that may be at hand, such as cinders, bits of coal, and the like. This covering is from one-half to 1 inch deep, and the sides of the mound are made as steep as the covering material will allow.

The mounds have from one to three funnel-shaped openings, and in a few cases a still larger number, through which the workers pass in and out. The large end of the opening is toward the outside, and the openings are commonly about one-third the distance from the base to the top of the mound. These openings are closed about sunset or during the day at the approach of a storm and opened in the morning about 8 or 9 o'clock in summer. The closing is done so well that a very close examination is necessary to determine where the openings have been.

On hot days in summer the workers return to the mound before noon and remain inside during the hottest part of the day, but on cool days the entire day is spent outside.

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[a] Compiled from Kansas Sta. Bul. 154.

Under the coarse covering of the mound is a rain-proof roof made of particles of soil cemented together. Beneath this the mound and the soil directly under it to a great depth is honeycombed with circular chambers from 1 to 3 inches across and from one-half to 1 inch high. These chambers are connected by galleries about three-eighths of an inch in diameter and of various lengths. Some of these chambers are filled with seeds of any kind that are small enough for the ants to carry and that are near to the mound; other chambers are occupied by the young in various stages of growth; and still others serve as rooms for the adult ants.

The ants are of three classes—males, fertile females, and sterile females; the latter is the working class and is by far the most numerous. It is estimated that large colonies may have 10,000 workers. The ants vary in length from three-sixteenths to seven-sixteenths of an inch. All the females have large mandibles and stings.

These ants are not pests in the usual sense of the word; as long as the country which they inhabit was sparsely settled they did no harm. Since the country has become more thickly settled, so that they come into close contact with man, they have become a source of annoyance.

The ant colonies are usually too scattering materially to decrease the yield of any important crop. Even in alfalfa, where the damage occasions most complaint, they are chiefly troublesome as an obstacle to harvesting. In a 7½ acre field at Hays City, Kans., thirty-four colonies had cleared a space amounting to between 1 and 2 per cent of the total area, and most of them had constructed mounds of sufficient size to compel the mowing machine to pull around them. To attempt to mow through or over them would have choked the machinery and ruined the cutting edge of the sickle. Should a driver have such trouble in passing over a mound it would be most unwise for him to stop and try to adjust his machinery, for such a disturbance would bring the ants forth in angry swarms, each individual eager to do her utmost to repel the invader. Every one that succeeded in getting on man or beast would seize clothing, hair, or skin between her mandibles, curve her abdomen downward, and deliver a thrust quite as painful in result as the sting of bumblebee or yellow jacket.

Even if the mounds be leveled some days before the cutting, the difficulty is merely lessened, for the passage of the team and machine over the nest is sufficient to bring the ants out in readiness to attack when the intruder comes around again. To a less degree the same difficulty is experienced in raking and loading the hay.

In the dooryard the ants not only render the lawn unsightly with their mounds but unhesitatingly attack the careless child who walks over or plays about their nest. In trodden paths the passage of man or beast is sufficient to bring them out ready for any unfortunate that may follow soon after, and in corrals their determination to defend their rights is a source of annoyance to stock.

The authors' study has failed to find any effective natural enemy of the ants, and a trial of various methods of killing them shows that fumigation with carbon bisulphid is the most satisfactory. The method is described as follows:

Carbon bisulphid is evaporated under a practically air-tight vessel over one or more of the opened gateways of the mound. The vapor formed, being heavier than air, sinks downward through the burrows into the lowest parts of the nest and finally comes to fill every chamber and passageway. Thus all the ants that are at home are suffocated. Many nests so treated were carefully opened to the lowest chambers and all the occupants found dead beyond possibility of doubt. Some nests were not opened until the next day after the fumigation and then not a living ant could be found. The following method of using carbon bisulphid has proven the easiest and most efficient tried. Start fumigation when gateways are open; take a vessel, such as a galvanized-iron washtub, and place it bottom side up in such a manner as to cover the openings and as much of the mound as possible; if there are more openings than the tub will cover they should be closed by throwing some of the surrounding soil over them; place under the tub, in a shallow pan or dish, near the opening, 1 to 3 ounces of carbon bisulphid, depending on the size of the nest; quickly pack soil around the edge of the tub, making it as nearly air-tight as possible; allow to stand thus for about five hours. The experiments show that breaking open the mound before setting the fumigation is of no advantage, nor did the practice of pouring the fluid into the broken-up mound give any better results than that of evaporating it from a shallow pan.

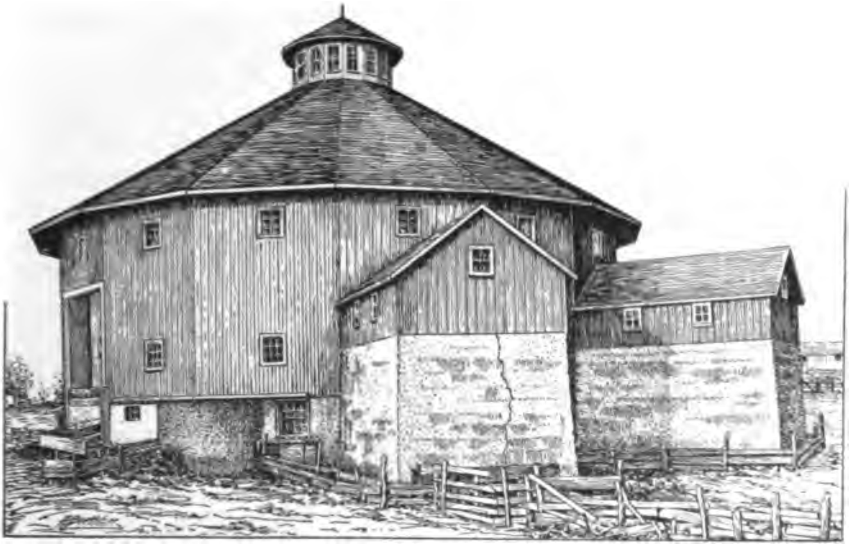

FIG. 3.—Square cement silos connected with barn. Not proper shape and too shallow.

It should be noted that carbon bisulphid is explosive and care should be observed in its use.

Since the reproducing members of the colony remain in the mound at all times, the above method would seem to be all that could be desired.

EFFECT OF GLASS, METALS, ETC., ON COAGULATION OF MILK IN CHEESE MAKING.[a]

One important problem with which the cheese maker has to deal is the irregularity in the coagulation of milk with rennet. This irregularity may be traced to a number of sources, such as variation in the strength of rennet extract used, the quality of the milk, and the kind of utensil employed. Experiments were made by G. A. Olson, of the

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[a] Compiled from Wisconsin Sta. Rpt. 1907, p. 134; Bul. 162.

Wisconsin Station, to discover the effect of different metals (platinum, tin, copper, nickel, iron, aluminum, and zinc) as compared with glass on the length of the coagulation period. "The experiments were conducted by placing milk in contact with [the] various metals for definite periods of time and afterwards observing the time required for the coagulation of such milk, with a standard solution of rennet, under uniform conditions." It was found that with the single exception of aluminum each of the metals tried produced a prejudicial (retarding) influence on the rennet action. The most striking influence observed was in the case of milk in contact with pure nickel. Milk which had stood in contact with this metal for twenty-five hours at 87° F. required four hundred and twenty minutes for coagulation with rennet and showed an acidity of 0.167 per cent. Under the same conditions milk in contact with glass required only nineteen minutes for rennet coagulation and showed an acidity of 0.207 per cent. However, as milk is hardly ever kept in nickel or nickel-plated utensils, the retarding effect of this metal has little significance from a practical standpoint. Copper also exerted a decidedly retarding effect, and as this metal is used more or less extensively in the form of heating disks in continuous pasteurizers in creameries and as kettles in the Swiss cheese factories, its retarding action is a matter of more practical importance. Apparently glass exerted a more or less accelerating influence on rennet coagulation and was to this extent beneficial in action. The degree of effect was directly dependent upon the character of the glass.

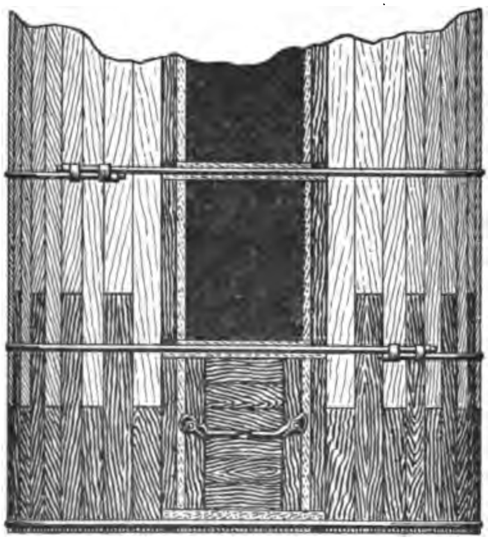

FIG. 4.—A silo with redwood staves at the bottom; cheaper wood above.

THE EFFECT OF RUSTY MILK CANS.

The experiments referred to above showed that both tin and iron have a prejudicial influence on rennet action. This suggested the desirability of determining whether or not rusty cans have a similar influence. Part of a sample of milk was placed in a rusty tin pan (with about fifteen rust spots in the bottom of the pan) and the remainder was kept in a Jena glass vessel (beaker) for comparative purposes. The milk kept in the rusty pan gave evidence of a retarding influence on the rennet action as compared with that kept in the glass beaker. "It required from one to sixteen and one-half minutes longer for the same milk kept in the rusty pan to coagulate than in case of the milk kept in the glass beaker." Wherever there was a retardation influence on the rennet action there was also a retardation of the acid development as well, but the latter was not sufficient to account for the delayed rennet action.

Milk which had been allowed to stand in iron dishes for several hours had a peculiar bluish gray color, indicating the presence of iron in solution. In several instances the amount of iron dissolved in the milk was determined as iron oxid. The maximum quantities of iron dissolved in the milk ranged from 1 to 1½ pounds for every 1,000 pounds of milk. The lower acidity of the milk kept in contact with iron also supports the view that the acid of the milk acts upon the iron and finally causes it to pass into solution [retarding rennet action].

Milk comes in contact with iron in the form of rusty cans or poorly tinned utensils in practically all creameries and cheese factories. The quality of the milk will to a large extent depend upon the condition of utensils into which the milk is poured, kept, and finally hauled to the factory. The degree of influence of iron on milk will depend largely upon the temperature of the milk, the length of time kept in the cans, and the amount of exposed surface.

Conditions in north European dairy countries.—In progressive dairy countries of northern Europe the quality of dairy products manufactured is generally uniform, and every precaution is taken to maintain a uniform product. Cleanliness is generally practiced at both the farm and factory. The utensils used are of superior quality, and naturally there is no occasion to consider this problem seriously. As a rule, the European utensils are stronger; the cans, for example, are of heavy steel and well tinned. Experience shows that these heavy cans are the most economical in the long run, and there is less danger of denting in or wearing off of the tin.

Conditions in America.—It is not necessary to describe here the American milk can, and especially the cheaper ones; if not the first time, surely the second or third time these cans are used one will find places where they have been dented in. As the number of indentations increase the tin begins to crack, leaving fissures or inroads for milk and water and acid. Often this thin layer of tin does not cover all of the iron, thus leaving microscopically small surfaces of iron exposed, which also become the sources of damage by water and acid. Under such conditions the tin peels or falls off, and it is then only a short time before the cans become unfit for use.

The attention of the milk producer and the factory operator is called especially to the following points:

(1) A better grade of utensils should be used in the handling of milk and its products. The iron or steel plate should be heavier and more thickly coated with tin.

(2) No milk should be accepted at a factory which has been kept in iron exposed pails or cans.

(3) The factory or creamery should be an example of neatness and cleanliness, with all utensils in first-class condition.

(4) Cooperation among the proprietors of creameries, cheese factories, and city milk supplies will tend to bring about cleanliness among patrons and the use of better utensils.

(5) Milk should be bought on its merits, by some satisfactory arrangement following well-founded sanitary and hygienic rules, by which the production of milk of superior quality is encouraged and milk of low grade either rejected or gradually improved.

THE EFFECT OF ALKALI ON CEMENT STRUCTURES.[a]

E. T. Tannatt, of the Montana Station, and W. P. Headden, of the Colorado Station, have recently called attention to certain facts observed in the course of their investigations which have a very important bearing on the use of cement in farm structures, a use which has rapidly grown with the increasing scarcity and advancing price of timber, viz, the action of alkali on the cement used in concrete structures.

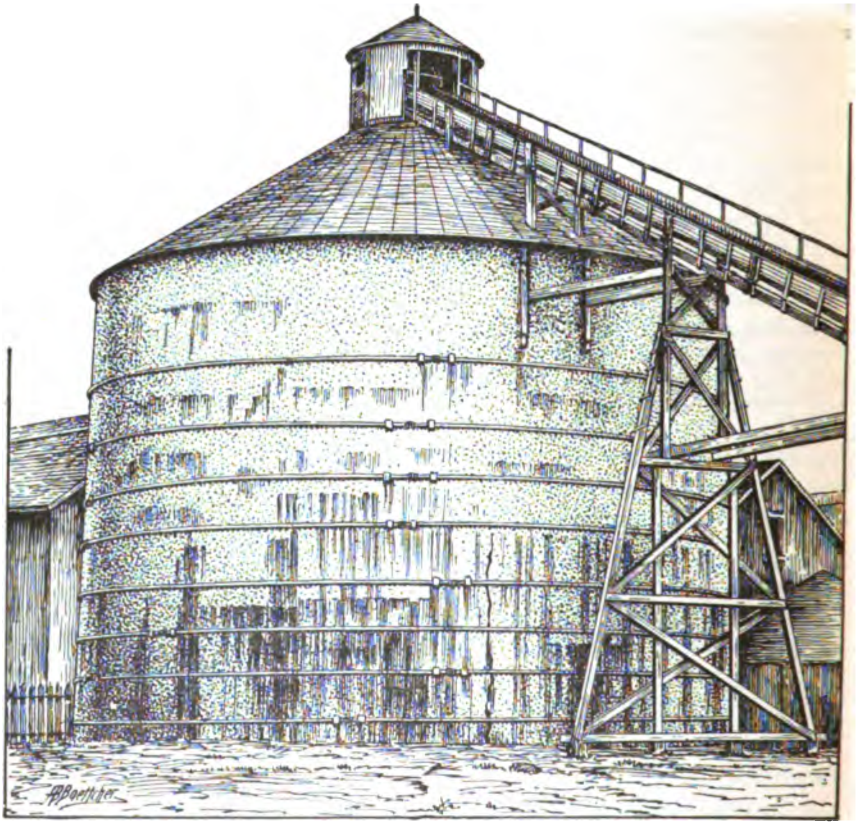

FIG. 5.—A large concrete silo which failed.

Professor Tannatt says.

> Cement is being generally used for the construction of culverts, flumes, bridges, foundations, retaining walls, curbings, etc. It has also been largely used in various parts of the canals, conduits, dams, etc., constructed by the United States Reclamation Service on their irrigation projects. A large number of the private irrigation and drainage projects of the West also make use of cement construction to a large extent. Conditions are pointing to a more general and larger use of cement in the structural works of the future. This material is also becoming more and more generally used in agricultural construction. In fact, it is difficult to prophesy to what extent cement may enter into the development of the resources of the country.

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[a] Compiled from Montana Sta. Bul. 69 and Colorado Sta. Bul. 132.

Professor Tannatt cites a number of cases of weakening or breaking down of cement structures due to the action of alkali. As "the distribution of alkali is quite general, being found throughout the arid and semiarid regions of the Western States and in the Great Central Basin," the damage which may result from this cause is of grave importance.

The examinations and chemical analyses (of a cement sewer) reported show that "the amount of disintegration corresponds closely to the percentage of alkali present." It was also found that sandstone is subject to similar disintegration under the influence of alkali. For this reason Professor Tannatt is of the opinion "that the use of sandstone in foundations, and for a couple of feet above the surface, is very inadvisable in the alkali sections."

As means of protection of foundations against the action of alkali it is suggested that—

> The ground on the exterior side should be excavated to the bottom of the foundation, the surface of the sandstone should be thoroughly cleaned with steel brushes and washed. Where the cement mortar shows signs of disintegration, the same should be removed and replaced with new material. After the surface of the foundation has been cleaned, the same should be given a good coat of hot asphalt, the coat extending sufficiently above the surface to include the alkali limit [2 feet above the surface]. In the bottom of the trench thus made along the foundation, a small tile should be laid which will drain any water away from the foundation, or into the city sewer. The trench, at least a portion along the face of the foundation, should be back filled with clean gravel or crushed rock to within a foot or so of the surface of the ground; above this may be placed earth for lawn, if desired.
>
> Concrete foundations for buildings are being used very extensively. Where any large amount of alkali is present in the soil, we believe that cement should not be used, unless thoroughly protected from the action of the alkali salts. This should be accomplished by thorough and proper drainage, and the use of some method similar to that suggested for sandstone foundations.

Professor Tannatt also calls attention to the possibility of harmful action of alkali in the case of cement sidewalks.

> In the construction of cement walks in the alkali sections, we would recommend that special care be taken to use clean gravel or broken stone. The use of soil in foundation gravel will furnish a means of bringing the alkali in contact with the lower portions of the cement. It is also advisable, we believe, that where the gravel or broken stone foundation is liable to become filled with water, to place a small drainpipe discharging into the gutter. We feel that with the present knowledge of the situation too much care can not be taken to prevent the alkali coming in contact with cement construction, either through the agency of standing water or the capillary action of the soil.
>
> The general recommendation is made that wherever cement construction is used in the alkali sections, a mortar made of granular sand should be used, and the mortar should be of maximum density.

SILO CONSTRUCTION.[a]

The general subject of silos and silage has been fully discussed in previous Farmers' Bulletins.[b] It is the purpose in this article, mainly on the basis of data reported by a number of the experiment stations, to point out some faults of silo construction which more extended experience has revealed, and to indicate, if possible, how these faults may be corrected and the general construction of silos improved, for, while it is generally conceded, by dairymen particularly, that the silo has become a necessity, occasional silo failures have discouraged the use of silage to some extent.

FAILURES OF SILOS.

Some of the failures of silos have been due to carelessness in filling, but more frequently to faulty construction of the silo.

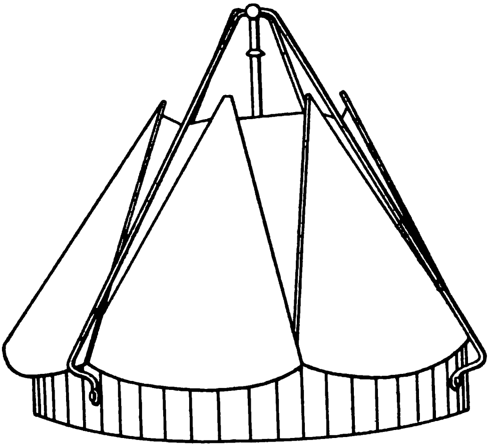

FIG. 6.—The patent roof of a silo, open.

Formerly many silos were made by sheathing one of the bays in the barn. With these silos and other forms of wooden square silos a lining must be built across the corners and the silage well tramped down along the edges or there will be considerable loss of what would otherwise be valuable stock feed. This style of silo, however, has become less common, and but few square silos of any kind are built at the present time. Even when silos are built inside of a barn they are often circular. Figure 3 shows a square silo that can not be recommended, not only because it is square but because it is not deep enough. The octagon silo is an improvement over the square form, but as a rule the walls of this form of silo have not been made rigid enough. The details for constructing the octagon silo were given in a previous Farmers' Bulletin.[c]

Too often the walls of silos are not made air-tight. Unless the walls of wooden silos are made air-tight, with tar paper, felt pads, or clay worked into the joints, much silage will be wasted. Ninety per cent of stave silos are not air-tight at the foundation. The shrinkage and swelling of staves breaks the cement, which must be frequently mended. Some losses have occurred because the ends of the staves have decayed. Figure 4 shows how some durable wood may be used at the bottom of the silo, which is one method of overcoming this difficulty. The iron bands of the stave silo must frequently be examined, or they will fall down as the staves shrink. Sometimes the iron splices rust. Unless a stave silo is well anchored it may be moved from its foundations or even blown down. A further discussion of the stave silo may be found in a previous Farmers' Bulletin.[a]

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[a] Compiled from Illinois Sta. Bul. 102; Iowa Sta. Bul. 100; Maryland Sta. Bul. 129; Wisconsin Sta. Bul. 125.

[b] U. S. Dept. Agr., Farmers' Buls. 32, 292.

[c] U. S. Dept. Agr., Farmers' Bul. 190, p. 21.

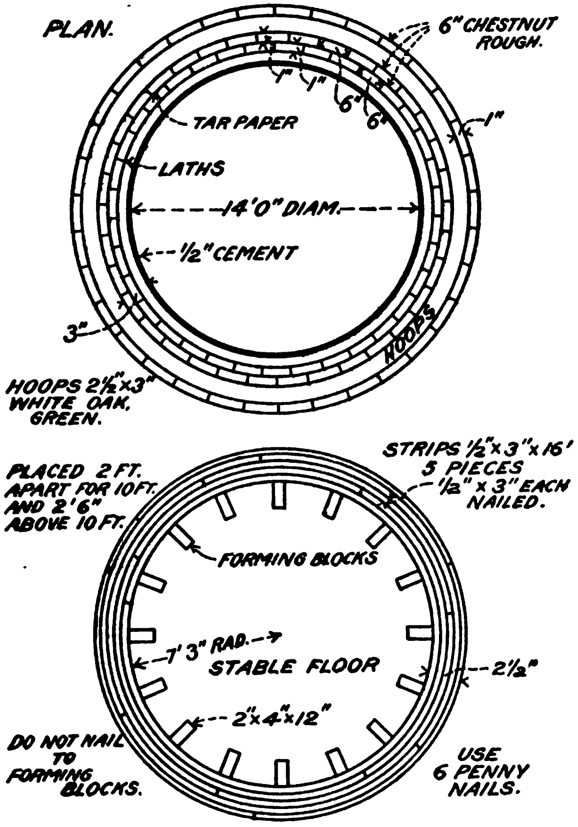
PLAN.
6" CHESTNUT ROUGH.
1"
1"
6"
6"
1"
TAR PAPER
LATHS
14'0" DIAM.
1/2" CEMENT
3"
HOOPS
HOOPS 2½"x3" WHITE OAK, GREEN.
STRIPS ½"x3"x16' 5 PIECES ½" x 3" EACH NAILED.
PLACED 2 FT. APART FOR 10 FT. AND 2'6" ABOVE 10 FT.
FORMING BLOCKS
7'3" RAD.
STABLE FLOOR
2½"
2"x4"x12"
DO NOT NAIL TO FORMING BLOCKS.
USE 6 PENNY NAILS.

FIG. 7.—Showing method of making hoops and details of the construction of a stone and stave silo.

The walls of the silo must be rigid or they can not stand the pressure. Figure 5 is an illustration of a silo, the concrete walls of which were not rigid enough to withstand the inside pressure. When the sides begin to bulge, air can get between the silage and the walls. Brick silos without reinforcement have been failures because of this pressure from the inside.

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[a] U. S. Dept. Agr., Farmers' Bul. 103, p. 23.

A mistake sometimes made was in building the silo of too large a diameter for the size of the herd, so that the silage spoiled by too long exposure of the surface. In one case a man with a small herd built a silo in his barn 18 feet square and 16 feet high. After two years' trial he gave up the use of the silo in disgust because his silage did not keep. A year or two later he sold his farm to a more progressive man, who built partitions across the same silo, making four small silos out of the large one, and had no difficulty in obtaining good silage for stock. The silos should be deep. The deeper the silo the better the silage. The diameter should conform to the size of the herd, and if 2 inches of silage are fed each day there will be no loss from surface exposure.

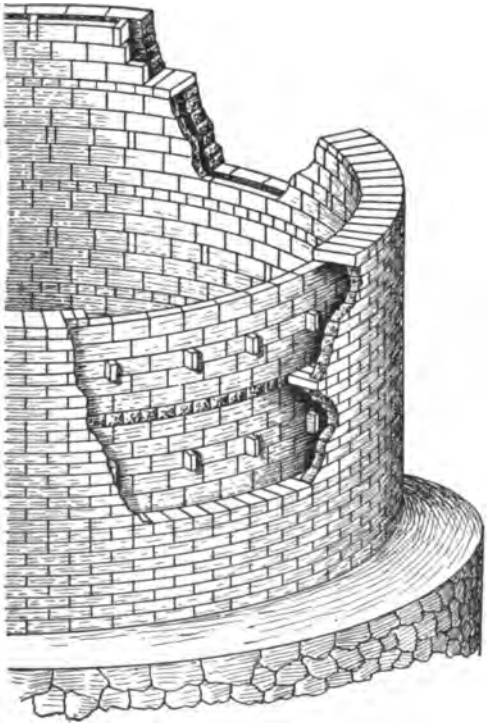

FIG. 8.—Double wall brick silo.

It is desirable to prevent silage from freezing. The double wall concrete silo and those built of rectangular building tile accomplish this object as well as any. Stone silos prevent freezing, but many owners of stone silos do not like them because moisture collects on the inside of the walls and rots the silage along the edge. A roof helps to keep out the frost, rain, and snow. Figure 6 shows a patent roof which allows the silo to be filled above the top.

MATERIALS FOR SILO CONSTRUCTION.

Most silos in this country are made of wood, but the high price of lumber has led to the use of other materials for all kinds of farm buildings. Experiment station workers have been investigating the desirability of using earthen and metal substances for silo construction. The cross section of a homemade combination of stone and stave silo in Baltimore County, Md., is shown in figure 7. Staves

20 feet long are set on a stone pit 8 feet deep and 14 feet in diameter, making a total height of 28 feet. The details of construction are as follows:

The staves on outside are chestnut, 6 inches wide, nailed on vertically 16 feet long, and 4 feet nailed above. The 4-foot pieces are nailed on so as to lap on the 16-foot pieces, allowing the water to run off.

The interior is vertically lined with 6-inch chestnut, tar paper placed, and again lined with 6-inch chestnut, joints being broken, then the vertical laths are placed, followed with horizontal, and then plastered with cement. The bottom is cemented in saucer shape. This silo is not affected by atmospheric conditions. The cement is not thick enough to cause it to sweat, and it is as perfect a preserver as the stone silo, there being no decay from sweating. This manner of construction is the only perfect combination silo that was found. The stone and frame work remain flush, thus allowing the silage to settle evenly, which is not the case in the stave silos, as the silo has to be placed in the center of the wall. If placed too near the pit, the shrinkage will allow the hoops to pull the staves to a smaller diameter than that of the pit and thus cause a leak at the foundation, this unevenness allowing the silo to fall or blow over. Every other space between hoops is a door; paper is used between door and joint. Stave silos with hoops ought not to be used as a combination silo.

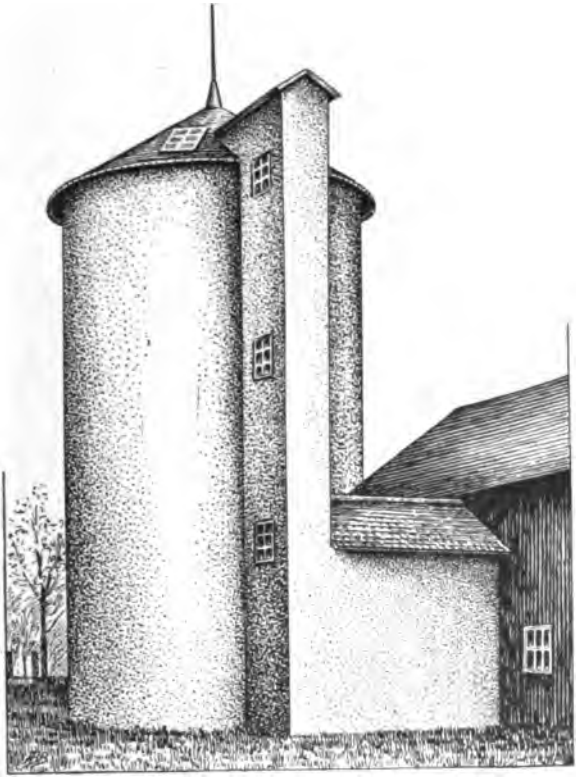

FIG. 9.—Double wall concrete silo.

The following is a list of the material required:

150 pieces ½ inch by 3 inch by 16 foot white oak for hoops.

50 pieces 1 inch by 6 inch by 16 foot chestnut staves	outside.
50 pieces 1 inch by 6 inch by 4 foot chestnut staves	
50 pieces 1 inch by 6 inch by 16 foot chestnut staves	inside first course.
50 pieces 1 inch by 6 inch by 4 foot chestnut staves	

One 16-foot piece nailed from top and 4 foot at bottom. Next stave 16 feet from bottom and 4 feet on top.

900 square feet of tar paper.

50 pieces 1 inch by 6 inch by 16 foot chestnut staves	inside second course.
50 pieces 1 inch by 6 inch by 4 foot chestnut staves	

2,600 rough laths.
20 pieces 2 inch by 4 inch by 16 foot rafters for roof.
200 feet 1 inch by 6 inch sheathing.
2,000 shingles.
18-inch stone wall.
24 perch of stone or concrete.

Doors are concave, built of staves, lined with paper, placed on two concave battens.

It may be questioned whether steel silos will come into general use. Galvanized iron is an excellent method of protecting a wooden silo when located out of doors. Many stone silos have been built, but some care must be taken to make the inside walls smooth. Cement mortar should be used and the walls must be reenforced by building steel bands into the wall.

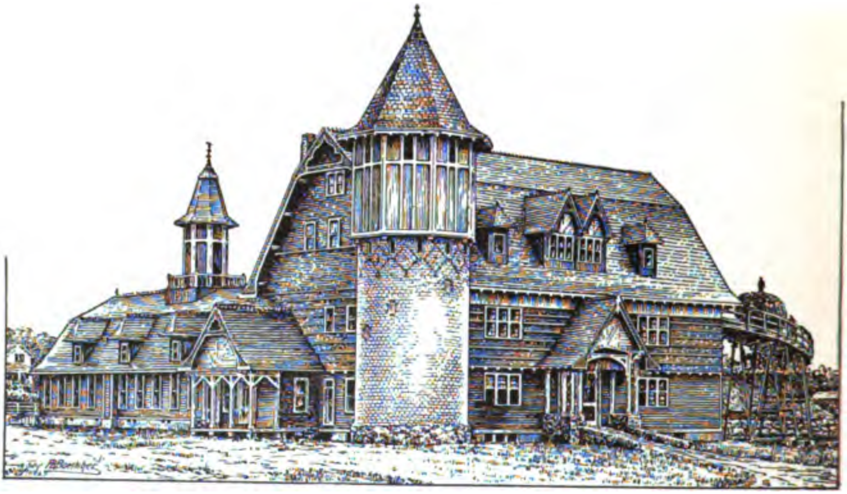

FIG. 10.—Dairy barn and stock-judging building, erected in 1898.

Clay pipe silos are giving good satisfaction, but are expensive. The tubes are set on end with the slots interlocking. Steel bands or hoops are placed around the wall and then plastered smooth with cement plaster. Rectangular building tile is recommended by the Iowa Station as a good material for silo construction. Cement block silos have been satisfactory when reenforced by steel within the walls. The inside of the silos should be plastered. The block is hollow and this prevents freezing. Brick silos are successful, but like the cement block must be reenforced in some way. Figure 8 shows a special form of double-wall brick silos.

The single-wall concrete silo is the most common style of construction. The thickness of the walls of silos now in use varies from 6 inches at the bottom to 4 inches at the top for the lightest wall to a wall 2 feet in thickness, which is the heaviest of which the section has record. Six inches seems to be the most desirable thickness for common sizes of silos under existing practice. The walls might be made lighter at the top, but the saving of material would hardly balance the trouble of varying the size of the forms. The double wall concrete silo at present is made only with a patented form. Figure 9 illustrates a double wall concrete silo made by forms owned by the Farmers Cooperative Concrete Silo Company. The inner wall is 5½ inches thick, the outer wall 3½ inches thick, and the two tied together with steel ties with a 3-inch air space between. Circulation is prevented by inserting horizontal tar paper partitions every 3½ feet. This construction, besides being as satisfactory as the single-wall method, places it entirely above any criticism in regard to freezing. The patent forms being of steel plate enable a very smooth job to be secured.

THE APPEARANCE OF THE SILO.

The silo as sometimes constructed is anything but an ornament to the farm. The situation and the style of architecture of the other buildings must be considered if the farmer takes pride in making his surroundings attractive. Figures 10, 11, and 12 show what may be done with the silo to make it an ornament instead of a disfigurement to the farmstead.

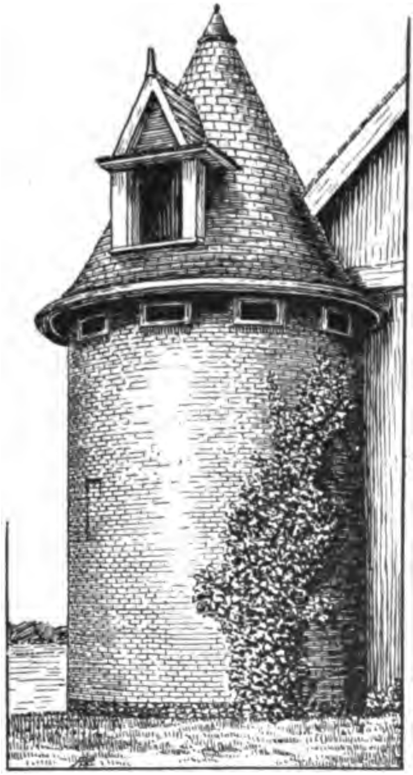

FIG. 11.—Brick silo, Iowa State College.

A CHEAP AND EFFICIENT STERILIZER.[a]

In a recent bulletin of the North Carolina Station, Prof. John Michels calls attention to the fact that "all vessels and appliances used in the handling of milk, cream, and butter should be rendered sterile after washing, either by placing them in boiling water for about five minutes or by steaming them for an equal length of time."

Small dairies without boilers should sterilize with hot water, but the larger dairies will find it advantageous to use a steam boiler and sterilize with steam. To perform this operation efficiently, it requires a closed steam chest large enough to hold everything that is to be sterilized. Sterilizers of this type are usually constructed of concrete, or brick and concrete, and are provided with a heavy iron door, this being large enough to admit a truck bearing the pails, cans, bottles, etc. Still other sterilizers of this type are constructed of galvanized iron or boiler plate, and all permit of sterilizing under more or less pressure.

The principal drawback to these various steam sterilizers is the high cost, which renders their use by the smaller dairymen almost prohibitive. After considerable experimentation and study, the writer has succeeded in constructing an efficient sterilizer which will cost only about one-third as much as the cheapest sterilizer of the type just mentioned. The construction of this new sterilizer, whose inside dimensions are 7 feet long by 2¼ feet deep, by 2¼ feet wide, is very simple. (See fig. 13.)

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[a] Compiled from North Carolina Sta. Bul. 198.

Essentially, it is a rectangular concrete tank with a wooden cover, which is lined with zinc. The sides and bottom are 5 inches thick and are built of concrete, which is made up of one part cement, two parts sand, and two parts coarse gravel. A thin coat, consisting of one part cement and two parts sand, is used as an inside finish. A piece of 2 by 4 studding is placed around the top of the tank and is secured by six ½-inch iron rods, 2 feet long, embedded in the concrete walls, one being placed at each corner, and one on either side midway between the corners. This arrangement not only strengthens the tank, but also makes the cover fit tighter.

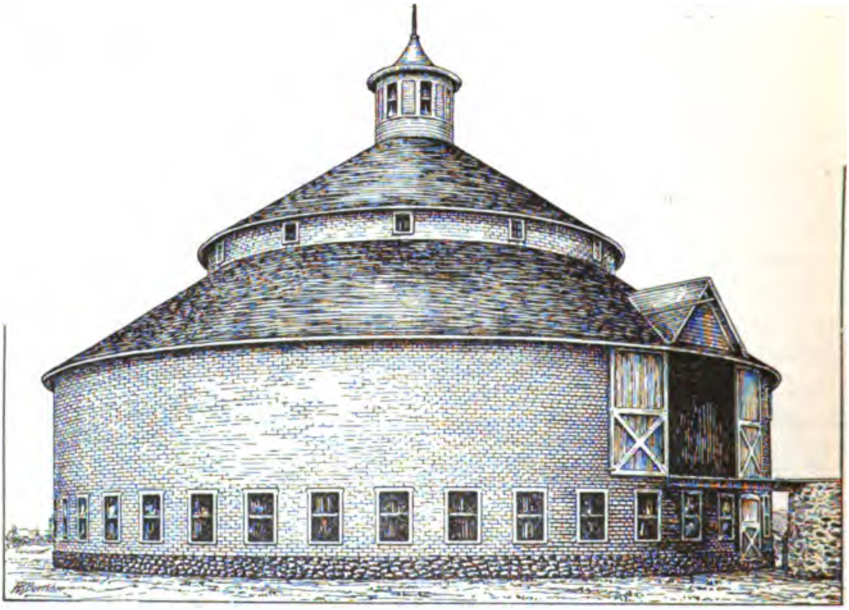

FIG. 12.—A circular dairy barn with silo in center 24 feet in diameter and 45 feet deep.

The cover consists of two thicknesses of 1⅛-inch tongued and grooved flooring 3½ inches wide. The upper boards run lengthwise and the lower crosswise of the tank. The lower boards fit into a shoulder projecting from the base of the 2 by 4 studding. The entire inside portion of the cover is covered with zinc. To insure additional tightness of the cover, a layer of asbestos is placed on top of the 2 by 4's. A safety valve, set at 10 pounds pressure, is inserted through the top of the cover at the most convenient place. An outlet for condensed steam is provided at the bottom.

The cover is raised and lowered in the same manner as that of the ice box described on page 29. The cover is strengthened by running three pieces of 2 by 4 studding crosswise of the tank, one at the middle and one at either end. The hinges, by which the cover is fastened, are attached to these 2 by 4 pieces, as shown in figure 13.

The following is an itemized statement of the approximate cost of the material of this sterilizer when the inside dimensions are: Length, 7⅓ feet; width, 2¼ feet; depth, 2⅓ feet:

2 barrels of Portland cement	$5.20
20 feet of 2 by 4 studding	.30
110 feet of 1⅛ tongued and grooved flooring, 3½ inches wide	4.40
4 hinges	.40
5 pounds nails	.20
6 ½-inch iron rods 2½ feet long	1.20
3 hasps	.30
20 square feet zinc	1.75
Ball and lever safety-valve	1.00
3 pounds sheet asbestos	.30
Total	15.05

The more extended use of efficient sanitary appliances on the farm should be encouraged, and this is most effectively done by indicating, as Professor Michels does in this case, cheap and simple methods of constructing such appliances. More sanitary methods of handling articles of food and drink would be more practicable and more generally used on the farm if some such convenient means of sterilizing appliances and utensils as Professor Michels describes were always at hand.

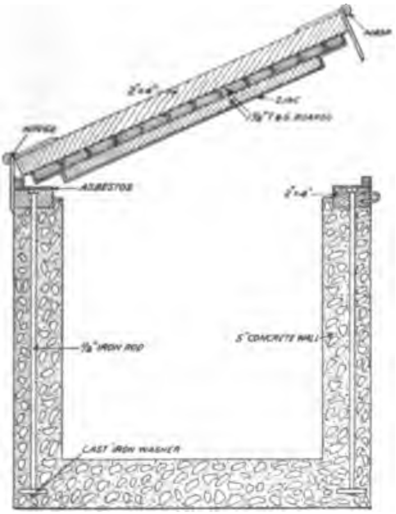

FIG. 13.—Cross section of sterilizer.

A CHEAP AND EFFICIENT ICE BOX.[a]

There is probably no need which is so severely felt on many farms, particularly in the South, as that of suitable cold storage for the preservation of meat, dairy products, and other food supplies, and as Prof. John Michels, of the North Carolina Station, points out, "cold storage of some kind is indispensable to a well-equipped dairy. Many, however, lack this essential, probably largely owing to the high cost of commercial refrigerators."

Professor Michels describes the construction of an easily made, cheap, and efficient ice box suitable for dairy purposes as follows:

The construction of the box shown in figure 14 consists essentially of two boxes separated by 1-inch strips placed at intervals of about 1 foot. Double thickness of building paper is placed on both sides of the strips and tacked to the boxes. A

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[a] Compiled from North Carolina Sta. Bul. 198.

1-inch strip 2 inches wide covers the upper space between the 1-inch strips, thus making a dead-air space between the two boxes. The construction of the cover is the same as that of the bottom, with the exception that there is a flange at the front and sides of the cover.

The sides, bottom, and cover of the refrigerator are built of ¾-inch tongued and grooved lumber 5½ inches wide. The ends are constructed of 1⅛-inch tongued and grooved flooring 3½ inches wide. The inside of the ice box is lined with galvanized iron. To insure tightness, a layer of felt is tacked around the box and cover where the two meet. The four vertical edges of the refrigerator are tightened and strengthened by tacking over each a double layer of paper, which is covered with two 6-inch boards.

A heavy weight attached to a ½-inch rope running over a pulley fastened to the ceiling raises the cover and holds it open when desired. A short piece of rope with a hook attached is used to counterbalance the weight by hooking to the side of the box, thus allowing the full weight of the cover to rest on the box.

A short piece of ½-inch gas pipe is inserted through the bottom of the box to provide drainage, the outlet of this pipe being immersed in a cup of water to prevent entrance of air into the box.

The entire construction of the ice box is so simple that anyone with a little knowledge of carpentry can readily build it.

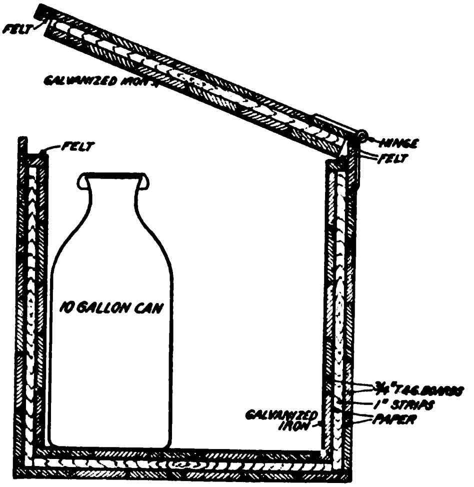

FIG. 14.—Cross section through ice box.

The inside dimensions are: Length, 7⅓ feet; width, 2¼ feet; depth, 2⅓ feet. An itemized statement of the cost is as follows:

200 feet ¾ inch by 5½ inch by 16-foot tongued and grooved lumber	$4.00
54 feet 1⅛ inch by 3½ inch by 16-foot tongued and grooved lumber.	2.16
168 feet 1 inch by 1 inch by 12-foot strips	1.26
4 hinges	.60
½ yard felt	.63
15 feet ½-inch rope	.30
2 strong hooks	.10
1 2-inch iron pulley	.50
Carpentry work, 3 days	6.00
Complete lining with galvanized iron	11.25
500 square feet building paper	.60
Total	27.40

Commercial refrigerators of equal capacity and no greater efficiency will cost from $60 to $100, or about three times as much as the refrigerator above described.

A test of this ice box for six days with an average of 200 pounds of ice in the box showed that an average temperature of 39° F. was maintained within it, with an average daily consumption of 40½ pounds of ice, while the temperature of the room in which the ice box was kept averaged 74° F.

When 22 gallons of milk, which had been cooled to 45° F., were stored in the box eight hours daily with the other conditions as above, the average daily ice consumption for six days was 49 pounds, and the average temperature of the box 40° F.

While this box is designed especially for dairy use, it may easily be adapted to other cold-storage purposes, and so extend its usefulness on the farm.

THE POWER LAUNDRY FOR THE FARM.[a]

In an extended article recently prepared for the State Dairy and Food Commission of Missouri by Prof. R. M. Washburn, who was then commissioner, valuable suggestions are made for the planning and convenient construction of barns with reference to location, hygienic conditions, interior arrangement, and conveniences. Special stress is laid on the use of power for running a feed mill and other appliances, and the use of boilers for supplying hot water and other similar equipment essential for satisfactory dairy farms. The modern cleanly, convenient, and hygienic dairy barn means a great deal of additional work for the farmer's wife and her helpers, for white suits must be washed and there is a general increase in laundry work and similar work. It is only just that these added burdens should be offset by more conveniences and labor-saving devices. In general, it is not true that the farm home has kept pace with the rest of the farm in the adoption of improved methods of labor-saving devices and other conveniences.[b]

Professor Washburn's plans for a model dairy barn include a laundry, and interesting figures on the cost of equipment, the length of time the equipment may be expected to last, and similar matters are given. It has been suggested that a laundry such as he proposes might be used by a number of families in the neighborhood on the payment of a small fee and prove of great value to the adjacent farm community. Such ideas of cooperation applied to rural life are interesting as well as valuable and an indication of a means by which the farm housewives' labors may be lessened in a number of ways. A cooperative bakery or laundry seems as practical as the cooperative creamery which is now so common.

Professor Washburn writes on the subject of the farm laundry as follows:

> A laundry provided with stationary washtubs, with washer and wringer for power use, is an innovation. But why should not the woman of the farm be provided with modern appliances? Why should she be compelled to toil as her great-grandmother did? The farmer no longer reaps with a sickle, or even with a cradle. He rides his plow, and often his harrow. He rides his grain drill and corn planter and corn cultivator. He rides his grain harvester and his corn harvester. He loads hay by machinery and pitches it into the barn by horse power. The time is come when it

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[a] Compiled from Ann. Rpt. State Dairy and Food Commissioner Missouri, 1 (1907), pp. 129-165.

[b] The general question of conveniences in farm homes has been discussed in Farmers' Buls. 270, 296, 317, and 342.

is positive cruelty to compel, or even allow, the woman to toil on without running water or machine power in the house. The same steam, water, and sewage system that must be present for the dairy will take care of the laundry. The same power used for grinding feed and separating milk and pumping water and sawing wood will turn the washer and the wringer. Prices will vary somewhat, but the following will be a guide to the cost of equipping such a room:

Equipment and cost of a farm laundry.

Equipment.	Dimensions.	Horsepower required.	Length of service.	Approximate cost.
Stationary tubs	3 compartments, each 28 by 25 by 17 inches.		20 to 30 years	$30
Power washer	24 by 32 inches	One-half	10 to 15 years	55
Power wringer	18 by 24¾ by 30 inches	do	15 to 20 years	40
Piping and connections			10 to 20 years	5
Drying room (¾-inch steam piping)			do	10
Total				140

The investment of $140 for one year at 7 per cent equals $9.80; deterioration, assuming that they will require to be replaced every fifteen years, equals $9.35 per year, or a total of $19.15, or, say, $20 per year, or 38 cents a week; add to this 10 cents more for gasoline used by the engine. If the farmer were compelled to kill and dress two hogs every week throughout the year he would think nothing of spending 50 cents a week for machines which would save so much labor and enable him to do more work in less time. A power ironer costing about $60 may be added, if desired. Such a laundry is to be desired, also, because it will practically insure clean garments worn by the milkers. A drying room, about 6 by 12 feet, located between the dairy room and the laundry room, provided with steam pipes for heating, will cost very little, and will insure quick, clean, and easy drying in any weather. A power laundry like this may be rented to the neighbors for, say, 50 cents per day, they to come over and do the work. Such an arrangement will in a measure lighten the burden now resting so heavily on the woman of the farm.

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FARMERS' BULLETIN 354.

ONION CULTURE.

BY

W. R. BEATTIE,

Assistant Horticulturist, Bureau of Plant Industry.

WASHINGTON:
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1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., February 6, 1909.

SIR: I have the honor to transmit herewith a manuscript entitled "Onion Culture," by Mr. W. R. Beattie, Assistant Horticulturist, and recommend that it be published as a Farmers' Bulletin to supersede the former publication of this title issued as Bulletin No. 39 of the same series.

During recent years the production of onions has become of great commercial importance, new methods have been adopted, and the Bermuda-onion industry of the Gulf Coast States has grown from a single experiment into an enterprise well worthy of consideration.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

- Introduction 5
- Areas adapted to onion culture 6
  - Climatic requirements of the onion 6
    - Length of season required for onions 7
    - Rainfall or irrigation 7
  - Soils adapted to onion culture 7
    - Clay and alluvial loams 8
    - Sandy loams 8
    - Muck and peat soils 8
- Cultural methods 8
  - Preparation of new land 9
  - Crop rotation 9
  - Preparation of the soil 9
  - Fertilizers 11
    - Animal manures 11
    - Commercial fertilizers 12
  - Propagation 14
    - Planting the seed 14
    - Planting distances and seed required to plant an acre 14
    - Thinning 15
    - Transplanting method of growing onions 15
    - Propagation by sets 17
  - Methods of tillage 17
    - Hand cultivation 17
    - Horse cultivation 19
    - Hand weeding 19
  - Irrigation 20
  - Harvesting and curing 21
    - Condition of bulbs when ready to harvest 22
    - Methods of handling the bulbs 22
  - Storage 24
    - Conditions required in storage 25
    - Methods of storing 26
  - Marketing 27
    - Grading 28
    - Shipping packages 28
    - Weight of onions 29
  - Important commercial varieties of onions 29
    - Common market varieties 29
    - Other types of onions 29
- The production of Bermuda onions 30
  - Soils and climate adapted to the Bermuda onion 30
  - Cultural methods 31
  - Harvesting and marketing 31
  - Yield of Bermuda onions and prices obtained 31

Page.
Green onions for bunching 32
  Type of onions employed 32
  Cultural methods 33
  Marketing 33
Enemies of the onion 33
  Onion smut 33
  Downy mildew 34
  Insects 35
Summary 36
  Cost of production, yield, and prices obtained 36
  Present relation between supply and demand 36

ILLUSTRATIONS.

Page.
FIG. 1. Harrow for smoothing and leveling the soil behind the plow 10
2. Disk plow used for refitting land 10
3. Device used for smoothing soil before seeding 11
4. Seedling onion plants trimmed ready for transplanting 16
5. Wheel hoe adapted to working onions 17
6. Special wheel hoes for cultivating onions 18
7. High wheel type of hoe 18
8. Small-tooth horse cultivator 19
9. Onion hoe 19
10. Hand weeder 19
11. Thinning or weeding hook 19
12. Irrigation ditches in Bermuda-onion field in Texas 20
13. Irrigation of Bermuda onions in Texas 21
14. Field of onions in condition for gathering 22
15. Onions drying in windrows 23
16. Method of curing onions in sacks standing in field 24
17. Grading onions in the field by means of a screen 25
18. Onion storehouses 26
19. Inside of storage house, showing method of stacking crates 27
20. Screen used for grading and cleaning onions 28

ONION CULTURE.

INTRODUCTION.

The onion in one or more of its several forms has been in use throughout all time of which we have authentic history. From available records it would appear that the original home of the onion was in southern Asia or in the countries surrounding or bordering on the Mediterranean Sea. During early times the onion was highly esteemed as an article of food, also as a preventive of thirst while on the march or traveling in the desert. In olden times the production of onions was confined to the alluvial river valleys, but the improvement and adaptation of varieties has made it possible to grow this crop under widely diverse conditions.

The onion belongs to the widely variable species *Allium cepa*, which forms a part of a botanical family of plants which includes many of the lilies, the several forms of asparagus and smilax, and similar plants having a scaly or fleshy enlarged root. A characteristic of this family is that most of its species grow naturally upon soil having an abundance of moisture, many of them being natives of low-lying areas along the seashore. Another characteristic of plants like the onion and asparagus is that they will withstand considerable salt in the soils on which they grow. The onion is grown primarily for its bulb; however, the leaves are often employed for seasoning, and there are several kinds that are grown for their leaves only.

The onion holds third place among the truck crops grown in the United States. In 1908 about 14,000,000 bushels, valued at $10,000,000, were produced, practically all of which were consumed in this country. In addition we annually import about 1,400,000 bushels from Spain, Egypt, Bermuda, and the South Sea Islands. The onion is one of the more common crops of our home vegetable gardens, and it is well adapted to growing commercially on a small scale, very little capital being required for a beginning. The market for onions includes practically the entire commercial world, and the demand for a good article continues throughout the entire year.

During recent years the production of the various forms of Spanish and Bermuda onions in the Gulf Coast States has become an industry in itself. Owing to the great quantity of this type of onion that can be grown upon a small area, a few thousand acres will produce all

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that the market can handle at a profit to the grower. In the alluvial delta region of the Mississippi River, the Egyptian onion is being grown to perfection, and there are doubtless regions bordering the Gulf of Mexico where the famous Denia onion may be produced as successfully as in its native Spain.

The object of this bulletin is to give brief information regarding the production of onions for market, including the history and characteristic features of the Bermuda-onion industry in the Gulf Coast States. The production of onion seed and "sets" is limited to certain localities and conditions, and for that reason this subject is not treated in this publication.

AREAS ADAPTED TO ONION CULTURE.

The onion is exceptional in that it will thrive under a very wide range of climatic and soil conditions. The crop is grown to perfection in the alluvial valley of the Nile River in Egypt, on the volcanic soils and under the tropical sea breezes of the South Sea Islands, along sandy coastal plains, in the irrigated portions of the arid regions, on sandy uplands, and on reclaimed swamp soils. There is perhaps no extended area in the United States, except the mountainous regions, where the onion can not be successfully grown.

CLIMATIC REQUIREMENTS OF THE ONION.

As already noted, the onion will thrive under a wide range of climatic conditions. For best results a temperate climate without great extremes of heat and cold should be selected. Onion culture is rarely profitable in regions where the climate does not change or has no definite seasons of heat and cold or wet and dry. Naturally the onion does best under rather cool conditions, with plenty of moisture during its early stages, but requires a reasonable degree of heat, together with dryness of both soil and atmosphere, for its proper ripening. Where the onion industry has become established in the extreme southern part of the United States, the growing season is during the late autumn and winter, the crop maturing during the spring and early summer. If the crop matures at a time when there is considerable rainfall, it will be impossible to cure the bulbs and they will be lacking in keeping qualities.

Certain types and varieties of onions, including the "top onions" and the "multipliers" or "potato onions," are extremely hardy and may remain in the open ground throughout the winters of our Northern States, especially if given slight protection. These types are, however, not adapted to growing for market, except as green onions, "peelers," or "bunchers," to be sold during the early springtime. In certain sections of the South Atlantic coast region large

areas of the top and multiplier onions are grown for this purpose. There is also a marked difference in the hardiness of the standard commercial sorts, some being adapted to growing far northward, while others, like the Bermuda, Egyptian, and Spanish types, thrive only in restricted southern localities.

Length of season required for onions.—The period required for the production of a crop of onions will depend upon the season, the methods employed in growing, and the variety. If grown from seed, a period of from one hundred and thirty to one hundred and fifty days will be required. If from sets, the crop may often be matured in one hundred days. If grown in the extreme northern part of the United States, where the seasons are short, the crop will mature more rapidly than to the southward. Onion seed grown at the North will as a rule produce mature bulbs in less time than that produced in a warm climate. In the case of the Bermuda onion, as grown in Texas, the growing season extends from the middle of September to the following March or April.

Rainfall or irrigation.—Onions require an abundance of moisture during the early stages of their growth, but should be ripened under comparatively dry conditions. In most sections the seed is sown at a time of the year when frequent spring rains occur. Their period of greatest growth is during the early part of the summer, and the crop is ripened late in the summer when drying conditions may be expected. In irrigated regions the application of water is almost entirely under the control of the grower. During the active period of growth the water is applied about once a week, the soil being thoroughly soaked and the surplus water drawn off.

The amount of rainfall or irrigation required for the production of a crop of onions will depend largely upon the character of the soil and its drainage. Many of the peat or muck soils in which the soil water remains near the surface will require very little rainfall; in fact, the best crops of onions are produced on these soils during seasons of comparatively light but evenly distributed rainfall. Sandy and loose soils generally will require a greater amount of water, especially during the early part of the season. Excessive rainfall or irrigation will have a tendency to produce onions having a large growth of leaves and stems at the expense of the bulbs. Onions of this character are commonly termed "thick necks" or "scullions."

SOILS ADAPTED TO ONION CULTURE.

The essential requirements of a soil upon which to grow onions profitably are a high state of fertility, good mechanical condition in order that the crop may be easily worked, sufficient drainage, and freedom from weeds. If a soil has the proper mechanical properties—that is, if it contains sufficient sand and humus to be easily

that the market can handle at a profit to the grower. In the alluvial delta region of the Mississippi River, the Egyptian onion is being grown to perfection, and there are doubtless regions bordering the Gulf of Mexico where the famous Denia onion may be produced as successfully as in its native Spain.

The object of this bulletin is to give brief information regarding the production of onions for market, including the history and characteristic features of the Bermuda-onion industry in the Gulf Coast States. The production of onion seed and "sets" is limited to certain localities and conditions, and for that reason this subject is not treated in this publication.

AREAS ADAPTED TO ONION CULTURE.

The onion is exceptional in that it will thrive under a very wide range of climatic and soil conditions. The crop is grown to perfection in the alluvial valley of the Nile River in Egypt, on the volcanic soils and under the tropical sea breezes of the South Sea Islands, along sandy coastal plains, in the irrigated portions of the arid regions, on sandy uplands, and on reclaimed swamp soils. There is perhaps no extended area in the United States, except the mountainous regions, where the onion can not be successfully grown.

CLIMATIC REQUIREMENTS OF THE ONION.

As already noted, the onion will thrive under a wide range of climatic conditions. For best results a temperate climate without great extremes of heat and cold should be selected. Onion culture is rarely profitable in regions where the climate does not change or has no definite seasons of heat and cold or wet and dry. Naturally the onion does best under rather cool conditions, with plenty of moisture during its early stages, but requires a reasonable degree of heat, together with dryness of both soil and atmosphere, for its proper ripening. Where the onion industry has become established in the extreme southern part of the United States, the growing season is during the late autumn and winter, the crop maturing during the spring and early summer. If the crop matures at a time when there is considerable rainfall, it will be impossible to cure the bulbs and they will be lacking in keeping qualities.

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worked, is retentive of moisture and fertilizers, and is capable of drainage—all other requirements can be met. At least three types of soil are being extensively planted to onions in this country, the one common essential being proper mechanical condition.

Clay and alluvial loams.—Soils of this character abound in the river valley and delta regions near the coast. These soils are generally very fertile, but will require the addition of humus or stable manure in order to lighten them. The greatest difficulty encountered in growing onions upon land of this character is the tendency of the soil to run together and bake after hard rains. This is especially injurious after the seed has been sown and before the small plants have attained sufficient size to permit of stirring the soil about them. Where these soils contain considerable sand they are ideal for onion culture. It is upon this class of soil that the greater part of the Bermuda, Spanish, and Egyptian onions are grown.

Sandy loams.—Sandy soils, especially where underlain by a well-drained clay subsoil, are often well adapted to onions. Soils of this character generally require heavy applications of fertilizers before they will produce a paying crop, but the quality of the product is excellent. Onions grown on sandy loams are generally solid, heavy, and of excellent keeping quality. Where sandy soils are lacking in humus this may often be supplied by means of crops of crimson or other clover grown upon the land and plowed under when it has attained its greatest growth. The use of leguminous crops should be supplemented by occasional applications of 1,000 to 1,200 pounds of lime to the acre.

Muck and peat soils.—Throughout the north central part of the United States there are vast tracts of peat or muck soils that are capable of producing onions. Before planting to onions, however, these soils must be cleared, drained, and brought to a suitable state of cultivation. In many cases this process will require two or three years' time, but sometimes the soil can be broken during the early winter, allowed to lie exposed to the action of frost for a few weeks, and planted to onions the following spring. Some of the largest onion farms are located on muck lands, and there are still great tracts of this class of soil waiting to be reclaimed.

The store of plant food in muck soil is usually large, but often it is not in available condition, and heavy applications of manure and commercial fertilizers, such as lime and potash, are essential to profitable crops.

CULTURAL METHODS.

The onion belongs to that class of crops which gives best results under very intensive culture, and the greatest yields are secured where a moderate acreage is planted and the work conducted in a most thorough manner. There is nothing technical or difficult about the growing of onions, but close attention and frequent cultivation are essential. Once the weeds get a start, the cost of production will be greatly increased, or the crop may be lost altogether.

PREPARATION OF NEW LAND.

As a general rule new land is not adapted to onion growing until it has been worked one or two years with other crops. Onions should follow some crop that has been kept under the hoe and free from weeds the previous season. Corn, beans, and potatoes are suitable crops with which to precede onions. Muck and sandy soils may in some cases be brought to a suitable condition for onions the first season, but the fitting will have to be very thoroughly performed. The land should be plowed in the autumn, then replowed in the spring, after which numerous harrowings and doubtless some hand work will be required to get the soil in suitable shape.

If necessary to manure the land heavily before planting to onions, it will be desirable to plant to some farm crop one season, then apply the manure during the autumn in order to give it time to become incorporated with the soil. Owing to the value of good onion land it would not be advisable to devote it to general farm crops for any extended period, although corn is frequently planted and oats or rye are sometimes used in the North. Cowpeas may be of great service in bringing new land into shape for planting to onions.

CROP ROTATION.

Onions should not be planted on the same piece of land year after year, and some system of crop rotation should be maintained. Care should be taken, however, to use crops in the rotation that will not be exhaustive of the high fertility necessary in the onion land. During the years when the land is not devoted to onions it can be planted to some truck crop that will give a return that will justify the application of large quantities of fertilizers, or, better, to a leguminous crop to be turned under as green manure. Continuous cropping with onions will cause the land to become infested with both disease and insect enemies that will sooner or later injure the crop to such an extent as to render it unprofitable.

PREPARATION OF THE SOIL.

Assuming that the land intended for planting to onions is capable of being brought to a good mechanical condition, fertile, well drained, and reasonably free from weed seeds, the first step in the production of the crop will be to plow moderately deep, then harrow, disk, roll, and drag until the soil is smooth and mellow to a depth of 4 or 5 inches. The method of preparing the soil will depend somewhat upon its character, the manner of planting to be followed, and the requirements for irrigation. There are few truck or other crops that require so careful fitting of the soil as do onions, and it is essential that the fertilizers be well mixed with the soil.

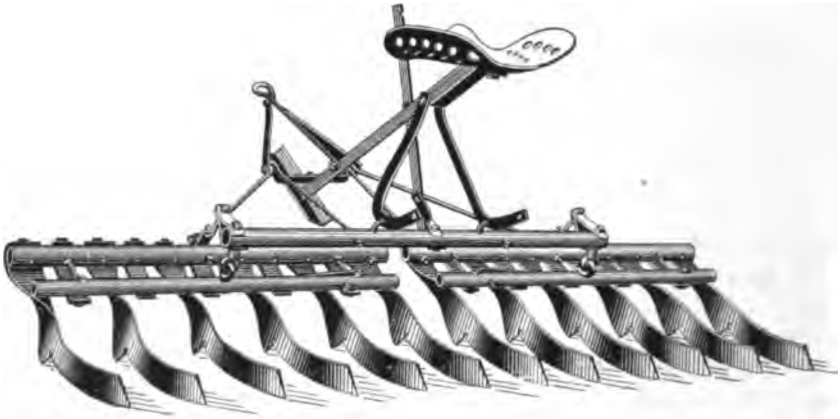

FIG. 1.—Harrow for smoothing and leveling the soil behind the plow.

On soils that are naturally well drained and where surface water can not accumulate, the plowing may be done in large blocks, but where the opposite conditions are found or irrigation is practiced it may be necessary to plow the land in narrow beds. In the case of insufficient drainage it will be desirable to throw the soil together into beds, leaving a double furrow between each bed to carry off surplus water. Where the flooding system of irrigation is practiced the beds must be leveled and a system of ditches and ridges provided for distributing and controlling the water. Where it is merely desired to secure surface drainage the beds may be from 75 to 150 feet in width, but for irrigation purposes the beds are generally but 12 or 15 feet in width. If

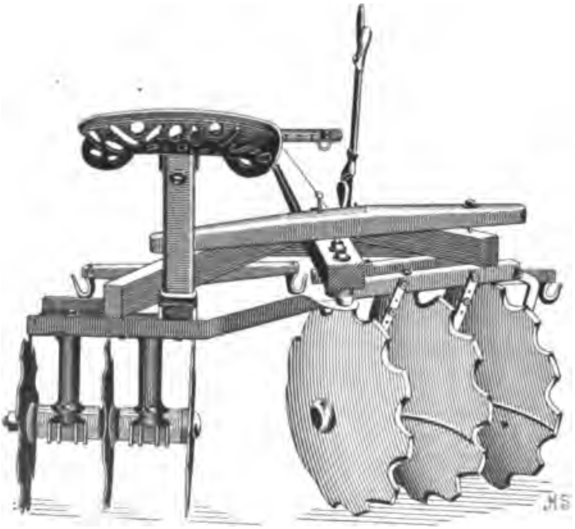

FIG. 2.—Disk plow used for refitting land.

spring plowing is practiced the soil should be harrowed closely behind the plow in order to prevent drying out.

For cutting and pulverizing the soil there is perhaps no tool as serviceable as the disk harrow. There is a type of disk having four gangs, in two sets, one combination in front of the other and so arranged that the soil is first turned to the center and then turned outward again by means of the rear combination. This tool turns the soil twice and leaves it in a level condition. For smoothing and leveling the soil behind the plow a harrow of the type shown in figure 1 is very desirable; this tool not only levels but turns and crushes the soil at the same time.

On land that has been plowed during the autumn and requires replowing in the spring, a device of the type shown in figure 2 will answer and will do the work more rapidly than the plow. This tool is especially adapted to bedding up land that has been previously plowed.

For imparting the final smoothing touch to the soil before planting there is a device consisting of a large number of small disks set in a wooden frame (fig. 3) which does about the same work as a steel rake, but in a rapid manner. A drag or float made from several pieces of scantling nailed together may be used for this purpose, or if the soil is very loose a roller should be run over it. The final leveling should be performed with a tool that will fill and obliterate all tracks or other depressions in the soil, leaving a smooth, even seed bed for either seed sowing or transplanting.

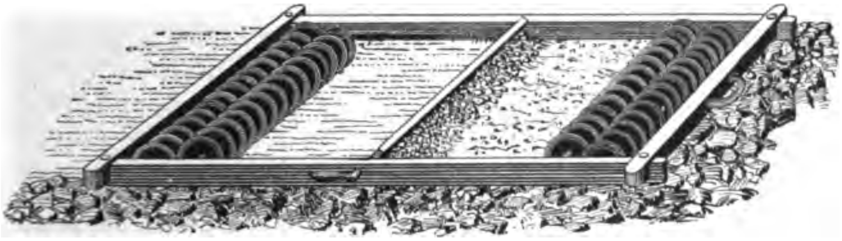

FIG. 3.—Device used for smoothing soil before seeding.

FERTILIZERS.

As the onion is an intensive crop and yields great quantities of marketable bulbs for the area planted, the grower is justified in manuring heavily. It would be difficult indeed to make the soil too rich for onions provided the manures are thoroughly incorporated with the soil. A heavy application of fresh raw manure just before planting would have an injurious effect, but where the manure is well rotted and uniformly applied there is nothing to be feared.

Animal manures.—There is perhaps no fertilizer so well adapted to the production of onions as plenty of clean, well-composted stable manure, and the quantity and frequency of application will depend upon the nature of the land under cultivation. The Bermuda-onion growers of southwestern Texas apply as high as 20 tons of sheep and goat manure to an acre every three years. In addition to the manure there is used 1,000 to 2,000 pounds of cotton-seed meal or commercial fertilizer, and sometimes a top-dressing of nitrate of soda. This sheep and goat manure is from animals that are fed largely upon cotton-seed meal, is saved in the corrals in a climate where there is very little rain, and it contains the essential fertilizing ingredients in very high percentages. The manure is first piled where a little water can be thrown over it and it is composted for several months before spreading on the land. The best results from this manure are not realized until the second or even the third year after its application.

All stable manure used on onion land should be well composted before use and then spread upon the land several months before planting to onions. In the Northern States the manure may be applied during the autumn and well disked into the soil. The land can then be allowed to lie in the rough state and exposed to the action of frost during the winter, or it can be smoothed and seeded to rye, in which case it will be necessary to replow during the early springtime. In the Bermuda district the manure should be applied during the springtime and the land kept frequently stirred during the summer months, with occasional irrigations in order to assimilate the manure and destroy weeds; the planting is not done until the autumn. Another practice in the Bermuda district is to apply fresh manure broadcast at the rate of 10 to 12 tons to the acre during the spring months, then plant to corn and cultivate through the early summer, and add a top-dressing of well-rotted manure after plowing the land for onions in the autumn. This top-dressing should be well worked into the soil by means of disk harrows. Large quantities of fresh manure applied to onion land just before planting will have a tendency to produce an overgrowth of tops at the expense of the bulbs. This is especially true on irrigated lands and soils that are naturally moist.

Commercial fertilizers.—Where there is an abundance of humus matter in the soil the onion crop will be greatly benefited by moderate applications of high-grade commercial fertilizers. A fertilizer that is suited to the growing of potatoes will serve quite well for onions, but the potash should perhaps be supplied in the form of muriate rather than of sulphate. A fertilizer adapted to the growing of onions should contain 4 to 5 per cent of nitrogen, 5 to 7 per cent of phosphoric acid, and 8 to 10 per cent of potash. A fertilizer of this character will cost $38 to $40 a ton and can be profitably applied at the rate of 1,000 pounds to the acre on most soils. Where very intensive culture is practiced it may be profitable to apply as much as a ton to the acre in addition to stable manure.

If it is found desirable to secure the ingredients and mix the fertilizer at home the following materials and proportions are suggested:

No. 1.—For use in the Southern States.

	Pounds.
Nitrate of soda, 14 to 16 per cent nitrogen	200
Cotton-seed meal	750
Acid phosphate, 16 per cent	750
Muriate of potash, 50 per cent	300

No. 2.—For use in sections where cotton-seed meal can not readily be obtained.

	Pounds.
Nitrate of soda, 14 to 16 per cent nitrogen	300
Dried blood	500
Acid phosphate	800
Muriate of potash, 50 per cent	400

No. 3.—For general use.

	Pounds.
Sulphate of ammonia, 25 per cent	200
Dried blood	300
Cotton-seed meal	300
Acid phosphate	800
Muriate of potash, 50 per cent	400

The ingredients of these fertilizers should not be mixed until shortly before they are to be used, as there is danger of loss from chemical action. In mixing, the proper quantity of all ingredients should be weighed and dumped together in a heap on a clean, tight floor. The work of mixing can be done by shoveling over three or four times, but should continue until all lumps are broken and the mass has assumed a uniform color and appearance.

Commercial fertilizers should not be applied until shortly before sowing the seed and should be uniformly distributed and thoroughly worked into the soil. There are one-horse fertilizer distributers that scatter the fertilizer broadcast, but where an amount not exceeding 1,000 pounds of fertilizer to the acre is being used the work of distribution may be performed by means of a common grain drill having a fertilizer attachment. On a small scale the work is generally performed by hand.

Many growers follow the practice of applying only a part of the fertilizer at planting time, reserving the balance to be put on as a top-dressing at some time during the period of cultivation. This plan is especially desirable where onions are grown during the winter, as the application of highly nitrogenous fertilizers in the autumn is liable to promote a soft growth that will be injured by cold. If the fertilizer is not put on until cold weather is over, the crop may be forced without danger of injury. For this purpose only those fertilizers of a very available form will answer. Nitrate of soda is frequently used as a top-dressing during the height of the growing period.

PROPAGATION.

Most of the onions grown in the United States are propagated from seed. Propagation from seed is conducted by three more or less distinct methods: First, by sowing the seed in the rows where the crop is to grow and mature; second, by sowing the seed in specially prepared beds and transplanting the seedlings to the open ground; third, by first growing sets from seed and then, after keeping them through the winter, planting them in the field to produce the crop of mature bulbs. Of these three methods the one first mentioned of seeding in the rows where the crop is to mature is the only one that is practical on a very large scale. Planting sets and transplanting have their advantages, but could not be applied on a large scale owing to the amount of labor required.

Planting the seed.—In the northern onion-growing districts the seed is sown as early in the spring as the soil can be brought to the proper condition. While it is desirable to plant quite early it never pays to sow the seed before the land is in the best possible condition. When the soil has been brought to a smooth, even surface and is fine and mellow, the seed is sown by means of one of the common seed drills, of which there are several makes upon the market. The hand drills which sow one row at a time are extensively employed, but many of the larger growers employ a gang of drills hitched together and plant from five to seven rows at once. A more even distribution of the seed will be secured by the use of the single-row hand drill owing to the closer attention that can be given the one machine. The first row may be planted with a line, and after this the marker on the drill indicates the next row. The drills are so arranged that the shoe and covering blades can be regulated to cover the seed at the proper depth, which will vary with different soils. In heavy or moist soils the depth to cover the seed should not be more than one-half to three-fourths inch, while on loose and sandy soils the seed may be covered an inch or more.

Planting distances and seed required to plant an acre.—Where hand cultivation is practiced throughout, the usual distance between rows is 12 or 14 inches. Where horse culture is employed the distance between rows varies between 24 and 36 inches. The quantity of seed required to plant an acre will depend both upon the distance between rows and the purpose for which the onions are being grown. For the growing of standard market onions in rows 14 inches apart, about 4½ pounds of first-class seed will be required. With the rows 3 feet apart, but 1¼ or 1½ pounds will be necessary. Where it is desired to produce small onions for pickling purposes, the amount of seed may be as great as 25 pounds to an acre. Good seed is essential, and if there is any doubt regarding the vitality of the seed it should be tested before planting by counting and planting four or five hundred seeds in a window box and then determining the germination by counting the seedlings after ten days' or two weeks' time. First-class seed is seldom sold at a low price and good seed at $1.50 or even $2.50 a pound may be cheaper in the end than poor seed at 50 cents. Old and inferior seeds are not only low in percentage of germination, but lack the vitality necessary to produce strong, healthy plants. There are dealers who make a specialty of securing and furnishing extra-quality onion seed, and while their prices are often somewhat above the general market the seed furnished by them is always preferable to ordinary seed.

Thinning.—Experienced growers are frequently able by using extreme care in regulating the drills to distribute onion seed in rows where the crop is to mature so that little thinning will be necessary. Thinning is generally left until the time of the first hand weeding, when all thick bunches along the rows are thinned to a uniform stand of eight or ten plants to the foot. It is always well, however, to allow for considerable loss of plants, and unless the plants are so thick as to actually crowd, thinning will not be necessary.

Transplanting method of growing onions.—The transplanting process, often spoken of as the "new onion culture," is merely a modification of the regular seeding method. The objects gained by transplanting are an earlier crop, a uniform stand, and bulbs of more regular size. Practically the entire Bermuda crop of the Southern States is handled in this manner. Where a small area is to be grown, the transplanting process is the ideal method, but for large acreages and where labor is difficult to obtain this would not be practical. After transplanting, the seedlings will require rain or watering in order that they may start, and for this reason the transplanting process is practically limited to areas where some form of irrigation is available.

In growing onions by the transplanting method the seed is sown in greenhouses, hotbeds, cold frames, or specially prepared beds at the rate of 3½ or 4 pounds for each acre to be planted. When the seedlings are grown under cover, they are given the necessary attention regarding watering and ventilation and kept growing quite rapidly until near the time for setting them in the open ground. As planting time approaches, the seedlings are "hardened" or prepared for transplanting by increased ventilation and exposure and by withholding water. When ready to transplant, the seedlings should be somewhat smaller than a lead pencil and rather stocky. The plants are lifted from the seed bed and the roots and tops both trimmed somewhat, as shown in figure 4. They are then packed neatly in shallow boxes for removal to the field where they are to be planted.

Various methods are employed for handling the plants in setting. As a rule, a line is used and the land marked to indicate the location of rows. Several methods are employed for marking the distance between plants in the rows; one method is by means of a line with small lead or brass indicators at regular intervals; another method is by means of a board having notches or holes in which a pointed dibble is thrust to form a hole in which to set the plant. A marking device much used by the Bermuda-onion growers in Texas consists of a sectional roller with the sections the same distance apart as the distance between the rows and each section provided with conical pins to form the holes in which the plants are set. The objection to the sectional roller marker is that it can not easily be drawn in a straight line and straight rows are essential to good cultivation.

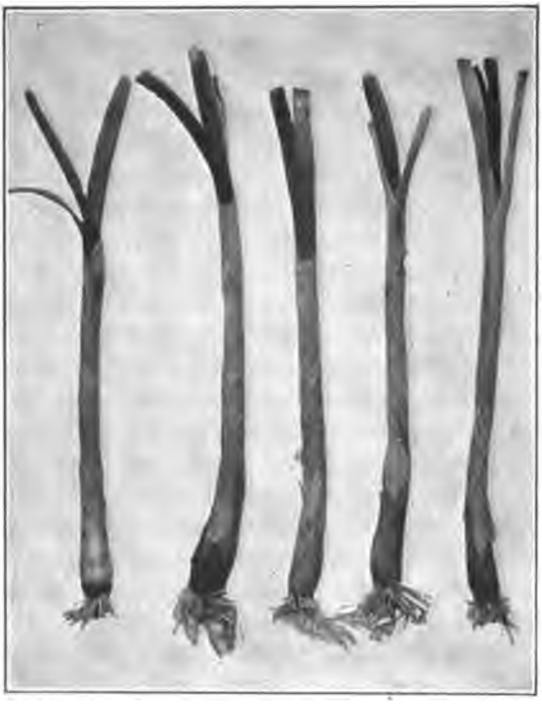

FIG. 4.—Seedling onion plants trimmed ready for transplanting. (One-half natural size.)

After marking the land, the plants are dropped ahead of the planters, or they may be kept in the trays and simply removed as planted. The transplanting process consists mainly in pushing the root end of the seedling into the soil with one finger and then firming the soil about the plant. This work is very laborious and can only be performed economically by very cheap labor. A small plow, such as is generally included with the attachments of the wheel hoe (fig. 5), is often employed for opening a furrow in which to set the small onion plants. As the plants are set the soil is either drawn about them by hand, or the plow may again be used for this purpose. In the Bermuda-onion district the work of transplanting costs from $15 to $25 an acre and is performed by laborers who are content with 50 or 60 cents a day, boarding themselves. The work of transplanting is as a rule done by contract at about $1.50 for each bed of one-tenth acre. In transplanting, all inferior plants should be rejected, thus insuring a more perfect stand and development.

Propagation by sets.—The use of sets is still another modification of the regular seedling method, in which the seed is planted one year to form the sets from which to grow a crop of mature onions the following year. Like the transplanting process the use of sets is limited in its application. Onions grown from sets will ripen earlier than those from seed sown in the field, but the use of sets for commercial onion growing is not so practical as transplanting seedlings. In planting onion sets a furrow about 2 inches deep is opened, the sets being dropped about 3 inches apart and firmly covered. For best results the sets should be placed in an upright position. The quantity of sets required to plant an acre will depend upon their individual size and planting distances, but it is generally between eight and nine bushels. The price of sets at planting time is generally about $2.50 a bushel, or $20 for an acre.

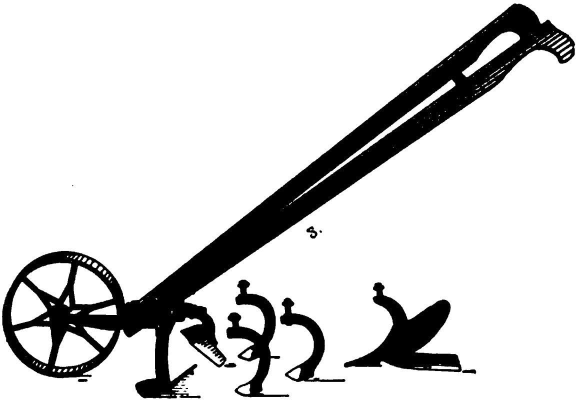

FIG. 5.—Wheel hoe adapted to working onions.

METHODS OF TILLAGE.

The cultural requirements of the onion are frequent shallow stirring of the soil and freedom from weeds. The feeding roots of the onion run close to the surface of the soil and should not be disturbed by deep cultivation. Sometimes a heavy rain immediately after seeding will so pack the surface that the seedlings can not break through. Under such circumstances it will be necessary to slightly break the surface by means of a steel rake or a rake-like attachment on a cultivator. As soon as the plants are up and the rows can be followed the cultivator should be started to loosen the soil, which is always more or less compacted during seeding.

Hand cultivation.—Where the rows are 14 inches or less apart, the work of caring for the crop must all be done by hand. For this purpose the wheel-hoe tools of various types are essential. These implements are provided with several kinds of hoes, cutters, and sweeps designed to work the soil away from the plants, to shave the surface and destroy weeds, and to stir the soil and work it back around the plants. Onions grown on muck and alluvial soils will require from eight to fourteen workings with the wheel-hoe implements; on sandy soils it will not be necessary to cultivate so frequently.

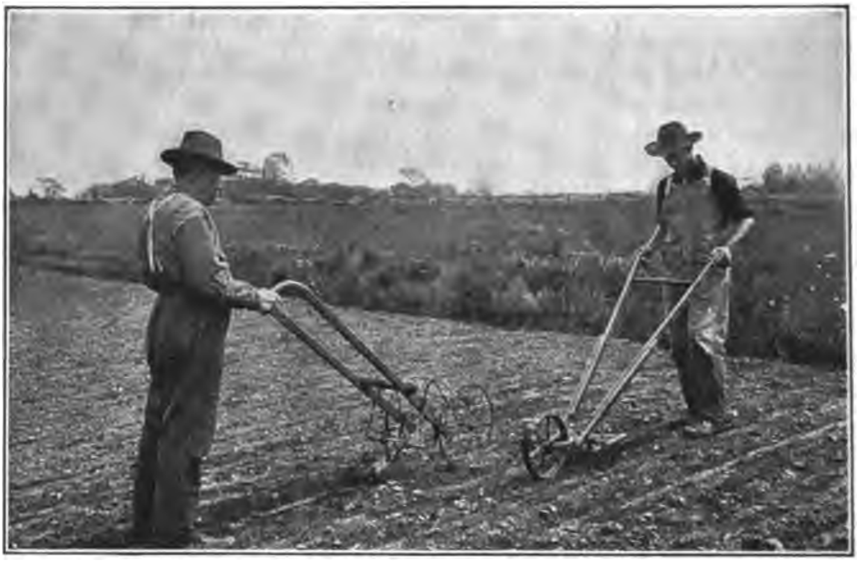

FIG. 6.—Special wheel hoes for cultivating onions.

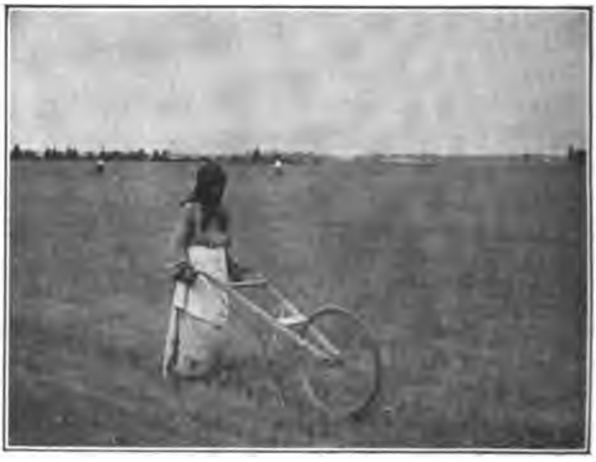

FIG. 7.—High wheel type of hoe. (Patented.)

Several types of wheel hoe are in use, but those having a single wheel and passing between the rows are most desirable. Those of the type in figure 5 are good. Many growers have designed special implements to suit the requirements of their soils; two of these are shown in figure 6, the one designed to cut the soil away from the row and the other to stir and work the soil back to the row. Some of the growers in the onion fields near Chicago have adopted a hoe-stock consisting of a pair of light plow handles, an iron stock, and the front wheel of a bicycle. To the stock of this device may be attached almost any form of sweep or cutter, and the implement is exceptionally easy to propel. The wide distance between the handles places the implement well under the control of the operator. Figure 7 will give an idea of the general appearance of this implement.

Horse cultivation.—In sections where onions are grown on a soil that is not well adapted to hand culture the rows are placed 30 to 36 inches apart and the cultivation is performed by means of horse-drawn tools. This is particularly true where onions are grown on the "black waxy" soils of Texas and other soils of the prairie type. As with hand culture, frequent shallow stirring of the soil is essential, the work generally being performed with one of the harrow-tooth cultivators. Those of the type shown in figure 8 are well adapted to this work. An implement known as a weeder can be used for breaking the surface before the seedlings appear; also for general cultivation by removing a tooth at the point where the rows are located.

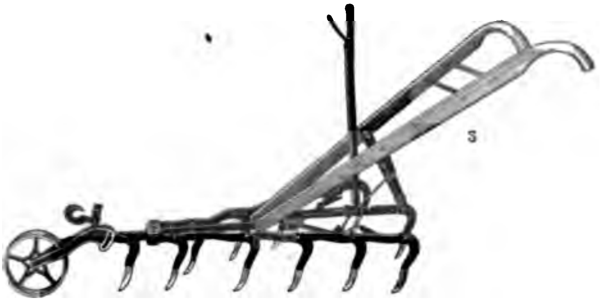

FIG. 8.—Small-tooth horse cultivator.

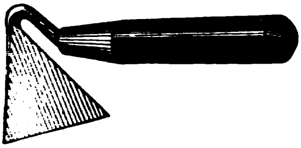

FIG. 9.—Onion hoe.

Hand weeding.—It is well-nigh impossible to produce a crop of onions without some hand weeding. During favorable seasons the strictly hand work may be reduced to but one or two weedings, but a greater number will be necessary during rainy seasons. Each hand weeding will cost from $5 to $12 an acre, according to wages paid and the number of weeds present. The work of hand weeding may be facilitated by the use of some of the small hand tools designed for the purpose. Among these tools might be mentioned the onion hoe, figure 9, the hand weeder, shown as figure 10, and the thinning or weeding hook, figure 11. Girls and boys are expert at hand weeding, the practice being to work them in gangs of ten to twenty with an overseer behind them to see that the work is properly done. In some localities the wages paid for this class of work are as high as $1.50 a day.

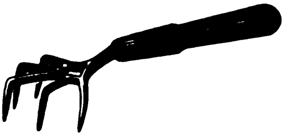

FIG. 10.—Hand weeder.

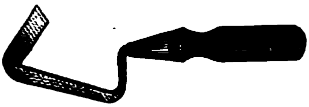

FIG. 11.—Thinning or weeding hook.

IRRIGATION.

Outside of the areas where irrigation methods are depended upon for the production of general crops it is not customary to use artificial watering in the growing of onions. In a few cases the land has been equipped with an overhead sprinkling system which is employed to moisten the soil after the seed is planted and also during extremely dry weather. On peat and muck soils the young seedlings are frequently lost by the dry muck blowing with the high winds of early springtime. In this way a part of the field may have the soil blown off to such an extent that the plants will be left without soil about them, while other portions of the field will be covered by 1 or 2 inches of loose muck. The use of a small quantity of water sprayed over the field will prevent this shifting of the soil during a windstorm, and thus save the crop from destruction. Sandy soils are also subject to the action of winds to a greater or less extent, and losses may be prevented by the timely application of water over the surface. In a few instances subirrigation is employed in the growing of onions.

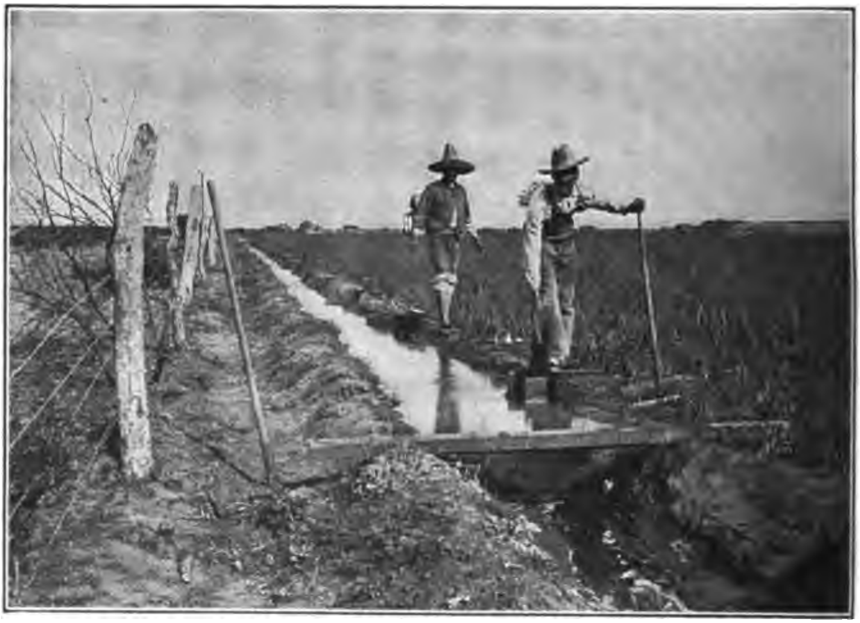

FIG. 12.—Irrigation ditches in Bermuda-onion field in Texas.

Throughout the Bermuda district of the Southwestern States surface irrigation is almost universally employed. The Bermuda onions are planted mostly in comparatively level beds with dividing ridges and are flooded once each week or ten days during the growing period. About a week before the plants are set the soil is flooded and then worked over with disk and smoothing harrows just ahead of the planters. Within a day or two after planting the land is again flooded and the surface water drawn off; this process is repeated, with alternate cultivations, as often as the land becomes dry. Toward the end of the growing season the water is withheld to allow the bulbs to ripen. As a rule about ten waterings in all are required, at a cost of about $1.50 an acre for each watering, or $15 altogether. Figures 12 and 13 will give a good idea of the methods of applying the water in the Bermuda-onion-growing district.

In the principal Bermuda-onion-growing districts the water for irrigation purposes is obtained only after the expenditure of thousands of dollars for pipe lines and pumping machinery, and the cost of watering as given above does not include any share of the original cost for installation.

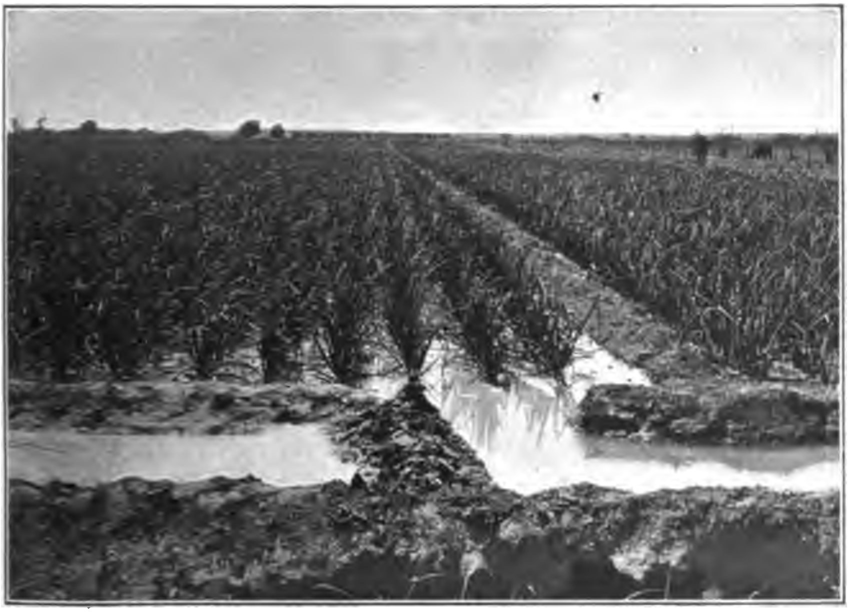

FIG. 13.—Irrigation of Bermuda onions in Texas.

HARVESTING AND CURING.

In the northern onion districts the crop ripens and is harvested during the latter part of the summer and early autumn. As a rule the work of harvesting onions begins late in July and is practically completed and the crop housed before October first. In the Southern States, where the crop is grown during the winter, the harvesting and marketing period is during the spring months and is practically ended before the northern product comes upon the market.

Condition of bulbs when ready to harvest.—In the North the bulbs are allowed to become as ripe as possible before removing them from the soil. Growers prefer that the tops ripen down and shrivel and that the outer skin of the bulbs be dry before they are pulled. Figure 14 shows a field of onions in prime condition for gathering. To the southward, where the onions are not cured so thoroughly, they are often pulled about the time that the tops begin to break and fall. The ripening process may often be hastened by rolling a very light roller or a barrel over the tops to break them down. This process is frequently spoken of as "barreling."

Methods of handling the bulbs.—Where the bulbs are practically upon the surface they may be pulled by hand and thrown in windrows consisting of eight or ten onion rows. If the onion bulbs are considerably covered with soil it will be necessary to employ a one-horse plow or a cultivator with a sweep attached for lifting them. In any case it will be necessary to gather them from the soil by hand. After lying in the windrows for several days and being stirred occasionally with wooden rakes they are gone over and the tops removed either by twisting or cutting with ordinary sheep shears. In cases where very bright color is important, as with fancy White Globe onions, and this would be injured by exposure to the sun and rain, the bulbs are cured in long, narrow, low ricks formed by two

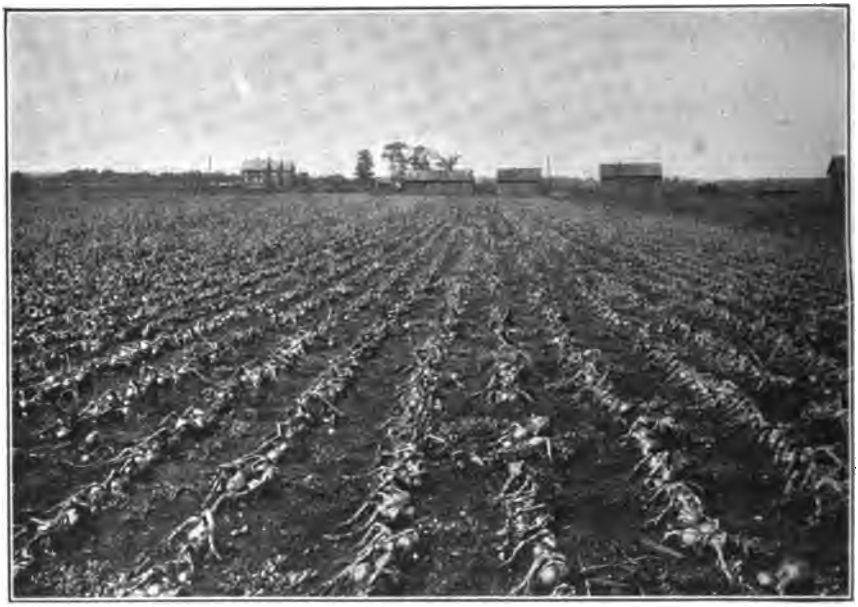

FIG. 14.—Field of onions in condition for gathering.

rows of onions laid with the bulbs regularly to the center, tops to the outside, the rows a few inches apart at the bottom of the rick but coming together at the top, and the top of the rick covered by straw or boards to shed the rain. As the tops are removed the bulbs are generally placed in crates for drying. In some sections onion-topping machines are employed, the bulbs being hauled from the field to a central location and run through the topper. These machines remove the tops, grade the bulbs, and deliver them into the crates or bags. If crates are not employed for curing, the bulbs are allowed to lie in the windrows for some time, and are then either put into sacks or hauled to slat cribs, where they complete the curing process. Too long exposure to hot sunshine will injure the bulbs.

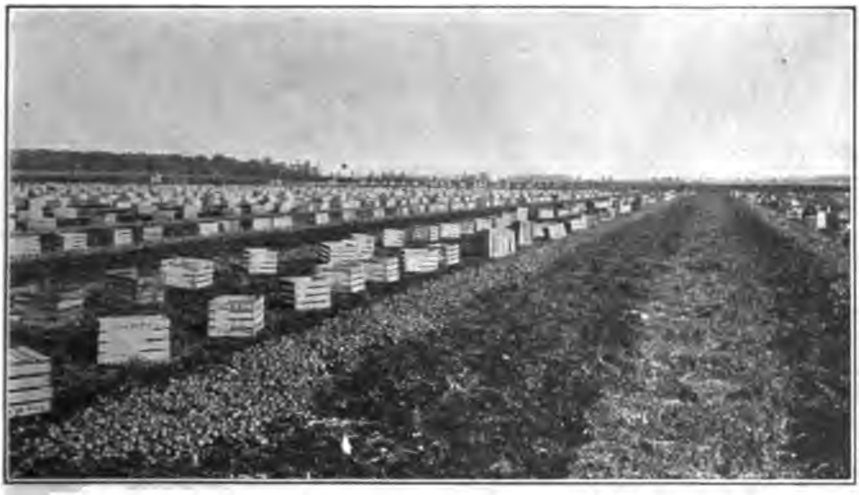

FIG. 15.—Onions drying in windrows, showing crates used for curing and storing.

Figure 15 shows a field of onions drying in windrows, with crates ready for their removal from the field.

After gathering into crates the crates are either stacked in the field, hauled to a central stacking yard, where the stacks of crates are covered with boards or canvas, or hauled to open sheds and there piled one upon the other with numerous air spaces until the onions are thoroughly cured.

Where the bulbs are extremely dry at the time of their removal from the soil, they may be allowed to lie in the windrows for a few days only, and then sorted and cleaned in the field ready for packing and marketing. Where onions are put into sacks and afterwards allowed to remain in the field, the sacks should be supported on poles laid upon the ground, as shown in figure 16.

In the Bermuda-onion districts, where very little attention is given to the curing of the crop, it is the practice to pack and load into the cars as soon as possible after pulling and topping. When the shipping is at its height, it is not uncommon for onions that are pulled from the soil in the morning to be in the cars and on their way to market by evening; however, a portion of the crop is given a more thorough curing process, and the entire crop would be benefited by at least two days of curing before shipment.

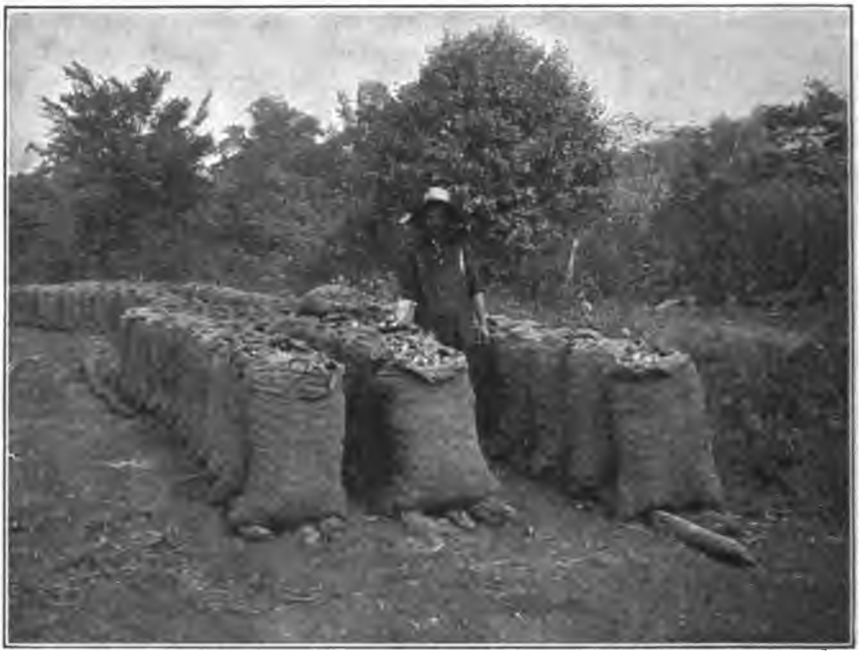

FIG. 16.—Method of curing onions in sacks standing in field.

STORAGE.

In order that onions should keep well when stored they must be well ripened and thoroughly cured. Those that are immature, soft, or "thick necks" should never be placed in storage but sold as soon as gathered for whatever price they will bring. Good storage onions will rattle almost like blocks of wood when poured from one crate to another. In order that the bulbs may remain bright and of attractive appearance they should not be allowed to lie exposed to the weather, but should be hauled and stored in open sheds just as soon as they may safely be placed in one-bushel crates.

After the bulbs have remained in drying sheds or cribs for several weeks they will be ready for screening and removal to the storehouse. In handling onions it is the rule to pass them over a screen each time they are moved, as in this way the loose skins are removed and any soft or decaying bulbs may be sorted out. When bags are used for drying in the field, the onions are screened in the manner shown in figure 17, and the bags refilled for hauling to the storage house.

In screening, the onions are placed on one end of the screen while the men stand alongside and stir the bulbs about with their hands, passing them along to the opposite end, where the bags are filled.

Conditions required in storage.—The essentials for the successful storage of onions are plenty of ventilation, storing in small quantities, a comparatively low temperature, dryness, and safety from actual freezing. Any building wherein the above conditions may be secured will answer, but houses of the type shown in figure 18, which are built especially for the purpose, are most satisfactory.

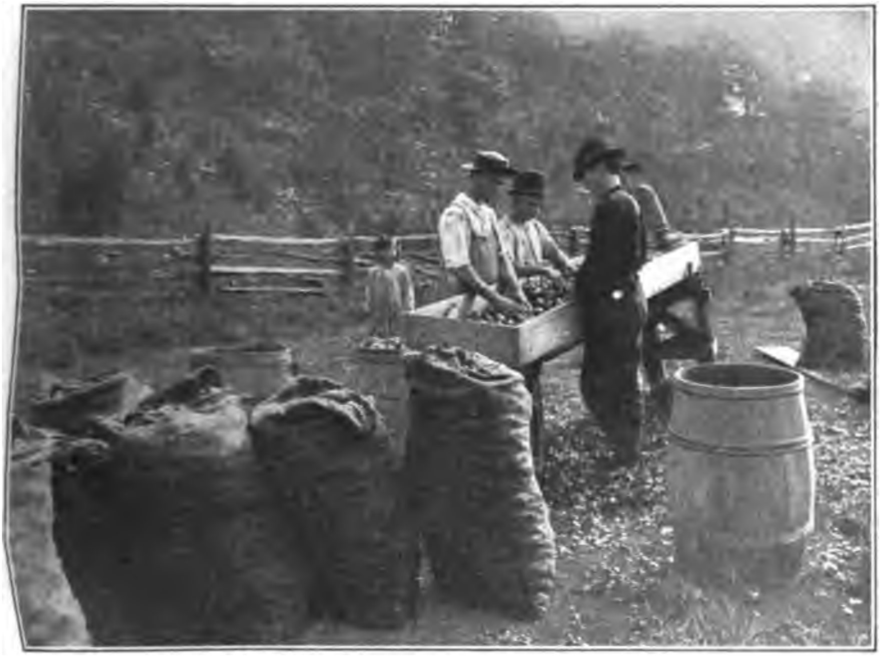

FIG. 17.—Grading onions in the field by means of a screen.

The construction of the storage house should be double throughout, with plenty of felt or paper lining. Both top and bottom ventilation should be provided and the ventilator openings should have doors that may be closed to control the temperature. The floors are constructed of narrow planks with half-inch spaces between the planks for the passage of air. Bottom ventilation is frequently secured by means of drain pipes built into the foundation at the surface of the ground. These pipes are carried some distance toward the center of the house and discharge the cool air at a point where it is most needed.

The temperature of the storage house should be carried as low as possible without actual freezing. During extremely cold weather the ventilator openings and doors should be kept closed to keep out cold, and after the onions have become thoroughly chilled the house should be kept closed in order to hold the temperature down and prevent the entrance of moisture during warm or rainy periods. Damp, foggy weather is injurious to onions, especially if it follows a period of cold, and will cause the bulbs to become covered with moisture if the outside air is admitted. A little artificial heat from a stove or radiator may be required during excessively cold weather, but so long as the temperature in the house does not fall below 33 degrees there will be no danger of injury. A temperature of from 34 to 36 degrees will give best results.

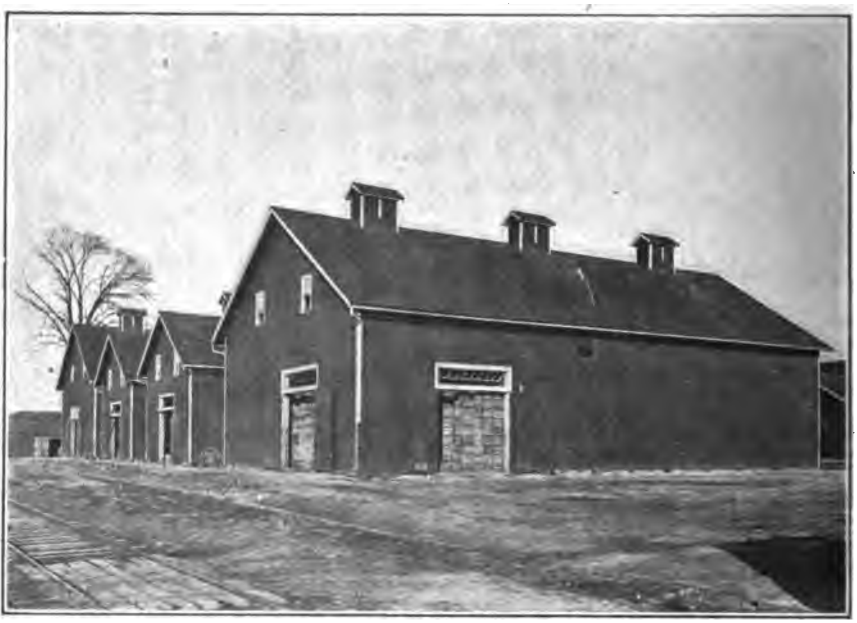

FIG. 18.—Onion storehouses.

Methods of storing.—The best method of storing onions is in standard size slat crates 20 inches long, 16 inches wide, and 14 inches deep, outside measurements. The material for the sides and bottom is about ⅜ inch thick and 2½ inches wide, four pieces being used to form a side. The corners are reinforced on the inside by means of three-cornered pieces of oak, to which the slats are nailed. These dimensions provide crates that are interchangeable, the width of five being equal to the length of four. These crates will also nest together when empty, with one inside of two turned together. The full crates are stacked in the storehouse with 1 by 3 inch strips between them to allow for the circulation of air, as shown in figure 19.

Onions are sometimes stored in slat bins holding 100 to 300 bushels each. Bags are also used to some extent, but neither bags nor bins are as satisfactory as the crates, owing to the difficulty in providing the necessary ventilation and change of air through the onions. Bulbs stored in bags or bins must be more thoroughly cured than those stored in crates. There are single large storehouses in use that will accommodate 50,000 to 60,000 bushels of onions when stored in crates.

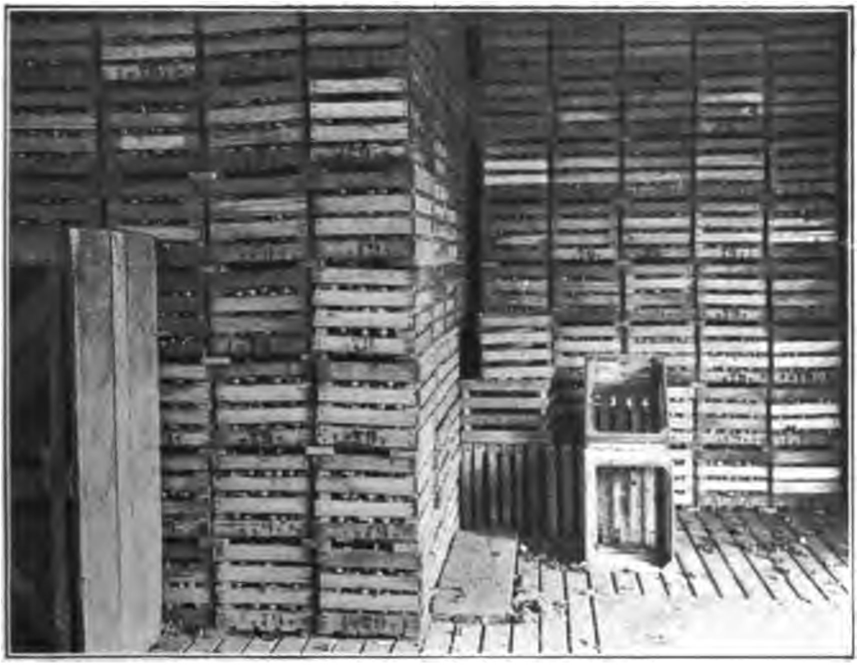

FIG. 19.—Inside of storage house, showing method of stacking crates.

MARKETING.

Large quantities of onions are sold and shipped direct from the fields where they are grown. A part of the crop is held in temporary storage until late autumn or early winter. During recent years the winter storage of onions has become of great importance and the finest stock is held for late winter deliveries. The Bermuda crop from the southwestern part of the country comes upon the market during April and May, so that most of the storage onions are disposed of before that time.

Grading.—In marketing onions the first essential is to properly grade and clean the bulbs, in order that they may present an attractive appearance when offered for sale. Ordinarily the bulbs are separated into three grades—primes, seconds, and "picklers." The primes include all those of 1¼ inches in diameter and larger, and the seconds consist of those from ¾ inch to 1¼ inches in diameter, while all those that will pass through a ¾-inch screen are sold for pickling purposes. The grading is generally done in the field during the cleaning process, but as onions shrink considerably while in storage it is necessary to regrade before placing upon the market. The type of screen used for grading onions is shown in figure 20. For cleaning the pickling onions an ordinary fanning mill is employed, special screens being provided for the purpose.

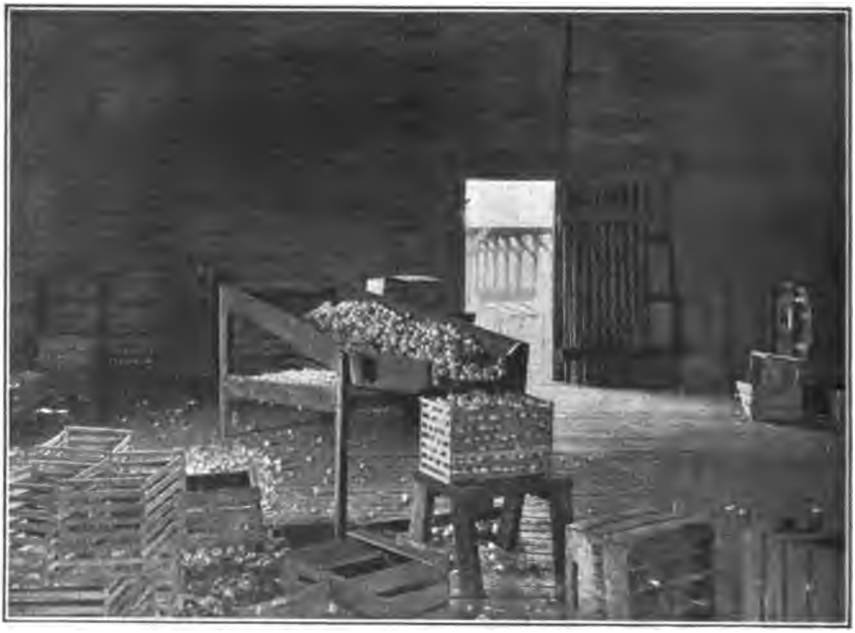

FIG. 20.—Screen used for grading and cleaning onions, showing folding crates largely used for marketing.

Shipping packages.—Onions are placed upon the market in crates, bags, barrels, Delaware baskets, one-half barrel baskets, and in bulk. The folding crate, shown in the foreground of figure 20, is undoubtedly the most attractive package in use for marketing onions. The bags employed are of heavy burlap and hold about the same quantity of bulbs as a barrel. The barrel in most common use is the same as is used for shipping early potatoes and holds about eleven pecks. These barrels are constructed of thin staves, have numerous openings for ventilation, and are headed with a piece of burlap. Standard apple barrels having two heads are also used for handling onions.

Onions are frequently shipped loosely in cars and shoveled into barrels or bags at their destination.

Weight of onions.—The legal weight of onions per bushel varies somewhat in different States, but 56 pounds of dry onions are generally considered a standard bushel.

IMPORTANT COMMERCIAL VARIETIES OF ONIONS.

Common market varieties.—The varieties of onions that have distinctively yellow, white, and red skins and are of the globular type are of greatest commercial importance. Among the varieties that belong to the yellow globe class are the Prizetaker, Yellow Danvers, Yellow Globe, Danvers, Southport Yellow Globe, and Ohio Yellow Globe. The principal white varieties are Southport White Globe, New Queen, Italian Tripoli, Silver Skin, and White Silver King. Among the more important red sorts are Red Globe, Red Wethersfield, and Australian Brown.

The principal Bermuda varieties are Red Bermuda, White Bermuda and Crystal Wax. The Bermuda onions are all of the more or less flat type. The red coloration of the Bermuda onion is not distinctive like that of the Red Wethersfield or Red Globe varieties, but is lighter in color. The famous Denia onion is somewhat of the Prizetaker type, is light yellow in color, grows to a large size, and is mild in flavor.

In the selection of varieties for any particular locality the soil conditions and market requirements should both be considered. Those adapted to the muck soils are the yellow and red sorts. For alluvial and prairie soils the red and brown varieties are to be preferred, while all kinds do well on the sandy loams and light soils. A cleaner, better grade of white onions can generally be produced on light or sandy soils than on muck or clay loams. Those of the Bermuda, Spanish, and Egyptian types flourish on the deep, rich alluvial soils of the river bottoms and delta regions.

Certain of our markets show a decided preference for onions belonging to a particular type. The red and brown varieties find ready sale on the markets of the Middle West, while onions of the yellow and white varieties are preferred in the eastern cities. Onions will withstand long-distance shipment, those of the Red Globe type being generally more subject to injury than the yellow and brown sorts. Some of the white varieties also have a thin skin and are easily injured. It should be the aim of every grower to employ varieties that will withstand handling and at the same time find ready sale on the market.

Other types of onions.—Among the types not already discussed are top onions, multipliers, garlic, and leeks, which are planted to some extent for marketing purposes.

The top or tree onion, which reproduces by means of small bulblets formed on the top of a seed stalk, is extensively used in the production of early spring bunching onions.

The multiplier or potato onion reproduces by a division of the bulbs. In growing this variety it is necessary to plant large bulbs to produce sets for the next year's planting and small bulbs or sets for the crop of large onions. The bulbs of this variety may remain in the soil year after year and are desirable for use early in the springtime.

Garlic is closely allied to the onion, but will remain in the ground from one year to another if undisturbed. Garlic is planted by setting the small bulbs, or cloves, in either the autumn or early spring. The culture is practically the same as for the onion.

The leek also belongs to the same class as does the onion, but requires somewhat different treatment. The seed is usually sown in a trench and the plants thinned to about 4 inches in the row. The plants of the leek are given about the same cultivation as onions, except that after they have attained almost full size the soil is drawn around them to a height of 6 or 8 inches to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored in cellars for winter use.

THE PRODUCTION OF BERMUDA ONIONS.

The production of Bermuda onions in the United States is a comparatively new industry and has thus far been undertaken mainly in Texas and California. Mr. T. C. Nye, now of Laredo, Tex., was perhaps the first to grow the genuine Bermuda onion in this country, his early trials being at Cotulla, Tex. The greater portion of the Bermuda industry of this country is now located in southern Texas and comprises from 5,000 to 7,000 acres in all. The Bermuda onion is also grown in southern California very successfully, and small areas are planted in southern Florida.

SOILS AND CLIMATE ADAPTED TO THE BERMUDA ONION.

Soils of a silty or alluvial nature are suited to the production of Bermuda onions, and those containing considerable sand are most desirable. As already noted in referring to fertilizers for onions, the Bermuda requires a very rich soil for the best results, and this can only be obtained by first selecting a good soil and then manuring heavily. The Bermuda onion as grown in this country is a winter crop; therefore, mild climatic conditions are required. While the plants would withstand considerable freezing, their growth is seriously checked by cold weather, and the crop will not mature in time for the early market if grown to the northward.

CULTURAL METHODS.

The cultural methods employed in the growing of Bermuda onions are essentially the same as those for ordinary onions. As the greater portion of the crop is grown in a region which has no regular rainfall, irrigation methods are employed almost universally. The greater part of the crop is grown by the transplanting process and a great amount of hand labor is required. The seeds are sown in specially prepared outdoor beds from the middle of September to the middle of October, and the seedlings are transplanted to the field November 20 to January 10, or even later. Three and one-half to four and one-half pounds of seed are required for each acre to be planted; this will allow for discarding all the weaker plants. The plants are allowed to remain in the seed bed until they are from $\frac{3}{16}$ to $\frac{1}{4}$ inch in diameter before they are transplanted. As the seedlings are lifted the greater portion of both the small roots and the tops is trimmed off in order that they may be transplanted more readily. (See fig. 4.)

HARVESTING AND MARKETING.

Bermuda onions are harvested as early as possible, generally before the tops have become fully ripened. For removing the bulbs from the ground a 1-horse plow, a potato digger, or a cultivator with a cutter wing attached is employed. The bulbs are then separated from the soil by hand, the tops cut off with shears, and the onions thrown in windrows or piles to dry in practically the same manner as for the regular-crop onions in the North. After the bulbs have become thoroughly dry on the surface they are either placed directly in the crates for shipment or are carried to a packing shed to be graded and packed for market.

During the early days of the Bermuda-onion industry the crop was shipped largely in bags, but it was soon found that the bulbs were too perishable for this method of handling. At present the greater portion of the crop is sent to market in folding slat crates that are about 20 inches long, 12 inches wide, and 12 inches high. These crates hold approximately 50 pounds of onions and weigh 56 or 57 pounds when filled. The cost of these crates is about $18 a hundred, but they add enough to the attractiveness and carrying qualities of the onions to make their use profitable.

YIELD OF BERMUDA ONIONS AND PRICES OBTAINED.

Phenomenal yields of 34,000 and 35,000 pounds of Bermuda onions are frequently made on an acre of land, but this is far above the general average, which is in the neighborhood of 10,000 or 12,000 pounds to the acre. Many fields, especially when planted for the

first time, do not yield as much as 10,000 pounds to the acre. On land that has been heavily manured and planted to onions for several years the yield averages about 16,000 pounds.

The prices paid the growers vary according to the market and condition of the crop, but are generally about $1.60 a hundredweight, the buyer furnishing the crates and loading the cars. With a normal yield of 16,000 pounds the returns would at this rate be about $250 an acre.

The cost of production will be about as follows: Preparation of land and fertilizers, $70; seed, $9; transplanting, $20; irrigation, $15; cultivation and hand weeding, $16; harvesting, $20; and interest on investment, $20, making a total of $170 an acre. On land that does not produce a full crop the expense is as a rule somewhat lower, the larger yields generally costing more for growing.

The best Bermuda-onion farms are valued at $300 to $500 an acre. In order to prove profitable, the growing of Bermuda onions should be conducted on a comparatively large scale. The necessary land and irrigation facilities will require the initial outlay of from $10,000 to $30,000, and the running expenses are quite heavy. Labor can be secured at a low price, but is correspondingly inefficient and often not to be had in sufficient quantities. Furthermore, the markets are now pretty well supplied with Bermuda onions, and persons who desire to engage in their production are advised to investigate every phase of the industry before embarking too heavily in it. The expansion of the Bermuda-onion industry is limited by the facts that a large supply of bulbs can be grown on a comparatively small area, that the distance to market is great, that the product is perishable, and that the markets will consume only a limited quantity at the prices at which the crop can be sold with profit.

GREEN ONIONS FOR BUNCHING.

Another phase of onion culture that is of considerable importance in certain localities is the production of young bunching onions for the early spring trade. In several sections along the South Atlantic coast the growing of this class of onions is quite an enterprise. Many persons who are engaged in other lines of work follow the practice of growing a small area of bunching onions as a side issue.

TYPE OF ONIONS EMPLOYED.

The varieties known as multipliers and top onions are generally employed for this purpose; however, bunching onions are sometimes grown from ordinary sets, from inferior and damaged large onions, and from seed. The multipliers and top onions are the only kinds adapted for this work on a large scale.

CULTURAL METHODS.

For growing bunching onions the bulbs or sets are planted during the autumn either in beds or in rows 12 or 14 inches apart with the bulbs quite close in the rows. The bulbs will start growing within a short time and make more or less growth during the winter. As soon as the weather becomes warm during the first months of spring the onions make a rapid growth and are ready for marketing about the time peach trees begin to bloom.

The land upon which these onions are grown should be rich and mellow, but very little actual cultivation will be required. Where the winters are severe it may be necessary to provide slight protection, either a little straw, loose manure, leaves, pine straw, or corn fodder that has been run through a shredder. If the onion beds are protected on the exposed sides by means of a wind-break consisting of a grove of pines, a fence of boards, pine boughs, or corn fodder, the crop will be ready for marketing a little earlier than if left exposed. The onions not gathered for marketing are allowed to remain to form the bulbs for planting the following season.

MARKETING.

In marketing this class of onions the young shoots are pulled, the roots trimmed, and the outside peeled off, leaving the stem white and clean. The onions are then tied in small bunches by means of a soft white string, the tops trimmed slightly, and the bunches packed in crates or baskets for shipment or sale on the local market. This phase of the onion industry is limited to small plantings and is well suited to the needs of the general market garden.

During the springtime and early summer large quantities of ordinary young onions are pulled when the bulb is about the size of a fifty-cent piece, the roots and tops are trimmed, and they are then bunched and sold for stewing purposes. So far as known, this class of onions is not shipped to any great extent, but is sold mainly on local markets.

ENEMIES OF THE ONION.

The onion crop of the United States is by no means free from both disease and insect enemies. Some of the enemies of the onion may be controlled without great difficulty, while others, if once established, can not be eradicated by any means known at present.

ONION SMUT.

The disease commonly known as onion smut is exceedingly troublesome on many soils that have been planted continuously to onions for a number of years. When this disease once becomes established in the soil it is very difficult to eradicate. Cases have been observed where land infested with smut was not planted to onions for ten years and where the smut reappeared in destructive quantities the first year that the land was again planted. Onion smut is a disease that can be carried with the seed or by cultivators and implements generally, or the spores may be carried by the wind. This disease first makes its appearance in the form of a swelling or hardening of the leaves, usually just above where they unite with the plant. After a time these places burst open and a powdery black dust, the spores of the fungus, emerge and are scattered broadcast. The disease attacks the entire plant and few, if any, good bulbs will be produced by affected plants.

Several remedies are offered for onion smut, none of which have proved entirely satisfactory. Soaking the seed for about twenty minutes in a solution consisting of 1 ounce of formalin in 1 gallon of water is recommended for destroying the spores that may adhere to the seeds. This process must be done but a short time before planting and the seed dried by means of plaster; however, the soaking of the seed will render it difficult to plant evenly.

Another method is to fit the seed drill with a small tank and allow a small stream of the above solution to flow into the row just behind the seed dropper and before the seed is covered.

A method frequently used by growers is to provide the seed drills with fertilizer attachments and apply a mixture consisting of 100 pounds of sulphur and 50 pounds of powdered lime in the rows with the seed.

On land that is free from smut, precautions should be taken to prevent its introduction. The danger of the spores being present with the seed is not great. The introduction is more often made by throwing diseased bulbs or tops in the manure pile and then hauling the manure on to clean land, or by the dragging of infested soil from one field to another with cultivators and other implements.

DOWNY MILDEW.

One of the serious onion troubles prevalent both in the Eastern States and on the Pacific coast is the downy mildew (*Peronospora schleideniana* De Bary). This usually occurs about midseason or when warm, muggy weather prevails. It causes a blighting of the leaves and is characterized in the earlier stages by a downy violet covering of the fungous spores, which in the later stages are less easily detected. Onions grown for seed are quite subject to attacks of mildew on both leaves and seed stalks.

Timely and thorough spraying with Bordeaux mixture will prevent the spread of downy mildew. If begun when the first signs appear the disease can be checked. It is better, however, to begin spraying before the mildew is due to appear. A good Bordeaux mixture for onions is made from 3 pounds of copper sulphate, 6 pounds of fresh lime, and 50 gallons of water.[a]

A suitable outfit is essential for success in onion spraying. A barrel sprayer operated by hand and with two leads of hose will fill most needs. Hand sprayers and the usual type of geared sprayers are ineffective because not thorough. The spray must be delivered under high pressure to break it up fine enough to adhere to the onion foliage, and the entire foliage should be covered. Repeat the spraying at intervals of about 10 days, depending on the weather and the growth of the crop.

To lessen the danger from this disease all onion tops from blighted fields should be burned and a rotation of crops practiced.

INSECTS.

The onion maggot is often very destructive in fields that are just planted. It works at the roots of the young seedlings and there is no entirely satisfactory means of combating it.[b] Crop rotation is one of the remedies recommended for its control, the land not being planted to onions oftener than once in three years.

Thrips belong to the class of minute sucking insects attacking the leaves, causing them first to assume a dull gray or dirty appearance and afterwards to turn brown and die. Onion thrips are very destructive in the South and are quite a serious pest in the Bermuda-onion district of Texas. Spraying with kerosene emulsion is one of the most efficient remedies, but thrips, it is claimed, may be repelled by spraying with a standard solution of Bordeaux mixture. It is noticeable that insects of this character generally attack crops that are grown on poor soil, that are late planted, or that are neglected as regards cultivation. Mr. Nye suggests, for Texas, planting the entire crop of Bermuda onions before January 1, so that the onions will be well advanced before March 1, at about which time the thrips begin to appear. According to observations, thrips do not gain a firm hold on a strong, vigorous crop, but they will practically destroy a crop that is inferior.

Cutworms frequently do great damage in onion fields by cutting off the young seedlings after they appear above ground.

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[a] Full directions for making and applying this fungicide will be found in Farmers' Bulletin 231, which may be obtained without cost upon application to the Secretary of Agriculture.

[b] For information relative to the onion maggot the reader is advised to secure a copy of Circular No. 63, Bureau of Entomology, U. S. Department of Agriculture.

SUMMARY.

COST OF PRODUCTION, YIELD, AND PRICES OBTAINED.

After all, the profits that may be obtained from an industry of this kind is the important consideration. The cost of growing an acre of ordinary onions by intensive methods will vary between $50 as a minimum and $150 as a maximum. In special cases, like the production of Bermuda and Spanish onions, the cost may run considerably higher. As a general average an acre of onions will cost in the neighborhood of $80 when ready to market. This does not include the crates or bags in which to market them.

An acre of onions will produce on an average 300 bushels, although large tracts are made to yield an average of 500 bushels an acre at a cost for growing not exceeding $75. The price paid the grower in the field is sometimes as low as 35 cents a bushel, although 45 cents is about the ruling price, taking one year with another. A yield of 300 bushels at 45 cents a bushel gives a gross return of $135 an acre, or about $55 with the cost for growing deducted. The more successful onion growers, and they are many, count upon a net profit equal to the cost of growing the crop.

In districts where the ordinary varieties of onions are planted in rows 3 feet apart and cultivated with horse tools, the yield is generally about 150 bushels an acre and the cost of production is frequently not more than $10 or $12 an acre. By this method the cost of production and returns are both comparatively low, but the margin of profit is very satisfactory.

PRESENT RELATION BETWEEN SUPPLY AND DEMAND.

Both the supply and the demand for onions are increasing and at present bear about an equal relation to each other. Some years the supply falls a little short and the prices go somewhat higher, with the result that larger quantities are imported. The following season the plantings are generally heavier, the market may be a little slow, and the result will be low prices and a great many people will discontinue the growing of onions. Every year there are a large number of persons who make a start in onion growing and who are successful. By reason of disease and change of soil and climatic conditions a considerable number of persons find it unprofitable to continue the growing of onions, and there is constantly room for the beginner.

The production of onions in a small way requires very little land or capital for a start, and is one of the most desirable occupations for persons who wish to live an outdoor life. The care of the crop brings the attendant in direct contact with the soil and is one of the greatest health-giving pursuits that come within the reach of persons of moderate means.

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FARMERS' BULLETIN 354

ONION CULTURE

W. R. BEATTIE

Senior Horticulturist, Office of Horticulture, Bureau of Plant Industry

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ONION CULTURE.

INTRODUCTION.

The onion in one or more of its several forms has been in use throughout all time of which we have authentic history. From available records it would appear that the original home of the onion was in southern Asia or in the countries surrounding or bordering on the Mediterranean Sea. During early times the onion was highly esteemed as an article of food, also as a preventive of thirst while on the march or traveling in the desert. In olden times the production of onions was confined to the alluvial river valleys, but the improvement and adaptation of varieties has made it possible to grow this crop under widely diverse conditions.

The onion belongs to the widely variable species *Allium cepa*, which forms a part of a botanical family of plants which includes many of the lilies, the several forms of asparagus and smilax, and similar plants having a scaly or fleshy enlarged root. A characteristic of this family is that most of its species grow naturally upon soil having an abundance of moisture, many of them being natives of low-lying areas along the seashore. Another characteristic of plants like the onion and asparagus is that they will withstand considerable salt in the soils on which they grow. The onion is grown primarily for its bulb; however, the leaves are often employed for seasoning, and there are several kinds that are grown for their leaves only.

Onions are one of the more important of our truck crops, the acreage in the United States during the four years from 1924 to 1927, inclusive, averaging about 70,000. The average yield per acre for this period was about 280 bushels and the total production equaled 41,000 cars of 500 bushels each. The onion is one of the more common crops of our home vegetable gardens, and it is well adapted to growing commercially on a small scale, very little capital being required for a beginning. The market for onions includes practically the entire commercial world, and the demand for a good article continues throughout the entire year.

During recent years the production of both Spanish and Bermuda onions has become firmly established as an industry in the United States. The production of Bermuda onions has developed largely in southwestern Texas, but there are other important producing sections, and it has been fully demonstrated that the Bermuda onion can be grown over a wide range of territory. The Spanish or Valencia onion is now grown on a large scale in several of the Western States, the quality of the onions produced being practically equal to those imported from Spain.

The object of this bulletin is to give brief information regarding the commercial production of onions, including the history and characteristic features of the Bermuda onion industry in this country. The production of onion seed and sets is restricted to more or less definite localities and for that reason is treated in a separate publication (Farmers' Bulletin 434).

AREAS ADAPTED TO ONION CULTURE.

The onion is exceptional in that it will thrive under a very wide range of climatic and soil conditions. The crop is grown to perfection in the alluvial valley of the Nile River in Egypt, on the volcanic soils and under the tropical sea breezes of the South Sea Islands, along sandy coastal plains, in the irrigated portions of the arid regions, on sandy uplands, and on reclaimed swamp soils. There is perhaps no extended area in the United States, except the mountainous regions, where the onion can not be successfully grown.

CLIMATIC REQUIREMENTS OF THE ONION.

As already noted, the onion will thrive under a wide range of climatic conditions. For best results a temperate climate without great extremes of heat and cold should be selected. Onion culture is rarely profitable in regions where the climate does not change or has no definite seasons of heat and cold or wet and dry. Naturally the onion does best under rather cool conditions, with plenty of moisture during its early stages, but requires a reasonable degree of heat, together with dryness of both soil and atmosphere, for its proper ripening. Where the onion industry has become established in the extreme southern part of the United States, the growing season is during the late autumn and winter, the crop maturing during the spring and early summer. If the crop matures at a time when there is considerable rainfall, it will be impossible to cure the bulbs and they will be lacking in keeping qualities.

Certain types and varieties of onions, including the "top onions" and the "multipliers" or "potato onions," are extremely hardy and may remain in the open ground throughout the winters of our Northern States, especially if given slight protection. These types are, however, not adapted to growing for market, except as green onions, "peelers," or "bunchers," to be sold during the early springtime. In certain sections of the South Atlantic coast region large

areas of the top and multiplier onions are grown for this purpose. There is also a marked difference in the hardiness of the standard commercial sorts, some being adapted to growing far northward, while others, like the Bermuda, Egyptian, and Spanish types, thrive only in restricted southern localities.

Length of season required for onions.—The period required for the production of a crop of onions will depend upon the season, the methods employed in growing, and the variety. If grown from seed, a period of from one hundred and thirty to one hundred and fifty days will be required. If from sets, the crop may often be matured in one hundred days. If grown in the extreme northern part of the United States, where the seasons are short, the crop will mature more rapidly than to the southward. Onion seed grown in the North will as a rule produce mature bulbs in less time than that produced in a warm climate. In the case of the Bermuda onion, as grown in Texas, the growing season extends from the middle of September to the following March or April.

Rainfall or irrigation.—Onions require an abundance of moisture during the early stages of their growth, but should be ripened under comparatively dry conditions. In most sections the seed is sown at a time of the year when frequent spring rains occur. Their period of greatest growth is during the early part of the summer, and the crop is ripened late in the summer when drying conditions may be expected. In irrigated regions the application of water is almost entirely under the control of the grower. During the active period of growth the water is applied about once a week, the soil being thoroughly soaked and the surplus water drawn off.

The amount of rainfall or irrigation required for the production of a crop of onions will depend largely upon the character of the soil and its drainage. Many of the peat or muck soils in which the soil water remains near the surface will require very little rainfall; in fact, the best crops of onions are produced on these soils during seasons of comparatively light but evenly distributed rainfall. Sandy and loose soils generally will require a greater amount of water, especially during the early part of the season. Excessive rainfall or irrigation will have a tendency to produce onions having a large growth of leaves and stems at the expense of the bulbs. Onions of this character are commonly termed "thick necks" or "scullions."

SOILS ADAPTED TO ONION CULTURE.

The essential requirements of a soil upon which to grow onions profitably are a high state of fertility, good mechanical condition in order that the crop may be easily worked, sufficient drainage, and freedom from weeds. If a soil has the proper mechanical properties—that is, if it contains sufficient sand and humus to be easily

worked, is retentive of moisture and fertilizers, and is capable of drainage—all other requirements can be met. At least three types of soil are being extensively planted to onions in this country, the one common essential being proper mechanical condition.

Clay and alluvial loams.—Soils of this character abound in the river valley and delta regions near the coast. These soils are generally very fertile, but will require the addition of humus or stable manure in order to lighten them. The greatest difficulty encountered in growing onions upon land of this character is the tendency of the soil to run together and bake after hard rains. This is especially injurious after the seed has been sown and before the small plants have attained sufficient size to permit of stirring the soil about them. Where these soils contain considerable sand they are ideal for onion culture. It is upon this class of soil that the greater part of the Bermuda, Spanish, and Egyptian onions are grown.

Sandy loams.—Sandy soils, especially where underlain by a well-drained clay subsoil, are often well adapted to onions. Soils of this character generally require heavy applications of fertilizers before they will produce a paying crop, but the quality of the product is excellent. Onions grown on sandy loams are generally solid, heavy, and of excellent keeping quality. Where sandy soils are lacking in humus this may often be supplied by means of crops of crimson or other clover grown upon the land and plowed under when it has attained its greatest growth. The use of leguminous crops should be supplemented by occasional applications of 1,000 to 1,200 pounds of lime to the acre.

Muck and peat soils.—Throughout the north central part of the United States there are vast tracts of peat or muck soils that are capable of producing onions. Before planting to onions, however, these soils must be cleared, drained, and brought to a suitable state of cultivation. In many cases this process will require two or three years' time, but sometimes the soil can be broken during the early winter, allowed to lie exposed to the action of frost for a few weeks, and planted to onions the following spring. Some of the largest onion farms are located on muck lands, and there are still great tracts of this class of soil waiting to be reclaimed.

The store of plant food in muck soil is usually large, but often it is not in available condition, and heavy applications of manure and commercial fertilizers, such as superphosphate and potash, are essential to profitable crops.

CULTURAL METHODS.

The onion belongs to that class of crops which gives best results under very intensive culture, and the greatest yields are secured where a moderate acreage is planted and the work conducted in a most thorough manner. There is nothing technical or difficult about the growing of onions, but close attention and frequent cultivation are essential. Once the weeds get a start, the cost of production will be greatly increased, or the crop may be lost altogether.

PREPARATION OF NEW LAND.

As a general rule new land is not adapted to onion growing until it has been worked one or two years with other crops. Onions should follow some crop that has been kept under the hoe and free from weeds the previous season. Corn, beans, and potatoes are suitable crops with which to precede onions. Muck and sandy soils may in some cases be brought to a suitable condition for onions the first season, but the fitting will have to be very thoroughly performed. The land should be plowed in the autumn, then replowed in the spring, after which numerous harrowings and doubtless some hand work will be required to get the soil in suitable shape.

If necessary to manure the land heavily before planting to onions, it will be desirable to plant to some farm crop one season, then apply the manure during the autumn in order to give it time to become incorporated with the soil. Owing to the value of good onion land it would not be advisable to devote it to general farm crops for any extended period, although corn is frequently planted and oats or rye are sometimes used in the North. Cowpeas may be of great service in bringing new land into shape for planting to onions.

CROP ROTATION.

Onions should not be planted on the same piece of land year after year, and some system of crop rotation should be maintained. Care should be taken, however, to use crops in the rotation that will not be exhaustive of the high fertility necessary in the onion land. During the years when the land is not devoted to onions it can be planted to some truck crop that will give a return that will justify the application of large quantities of fertilizers, or, better, to a leguminous crop to be turned under as green manure. Continuous cropping with onions will cause the land to become infested with both disease and insect enemies that will sooner or later injure the crop to such an extent as to render it unprofitable.

PREPARATION OF THE SOIL.

Assuming that the land intended for planting to onions is capable of being brought to a good mechanical condition, fertile, well drained, and reasonably free from weed seeds, the first step in the production of the crop will be to plow moderately deep, then harrow, disk, roll, and drag until the soil is smooth and mellow to a depth of 4 or 5 inches. The method of preparing the soil will depend somewhat upon its character, the manner of planting to be followed, and the requirements for irrigation. There are few truck or other crops that require so careful fitting of the soil as do onions, and it is essential that the fertilizers be well mixed with the soil.

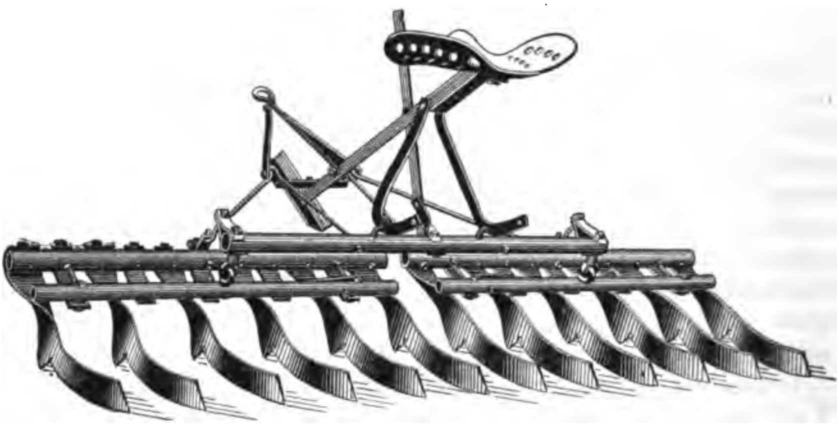

FIG. 1.—Harrow for smoothing and leveling the soil behind the plow.

On soils that are naturally well drained and where surface water can not accumulate, the plowing may be done in large blocks, but where the opposite conditions are found or irrigation is practiced it may be necessary to plow the land in narrow beds. In the case of insufficient drainage it will be desirable to throw the soil together into beds, leaving a double furrow between each bed to carry off surplus water. Where the flooding system of irrigation is practiced the beds must be leveled and a system of ditches and ridges provided for distributing and controlling the water. Where it is merely desired to secure surface drainage the beds may be from 75 to 150 feet in width, but for irrigation purposes the beds are generally but 12 or 15 feet in width. If

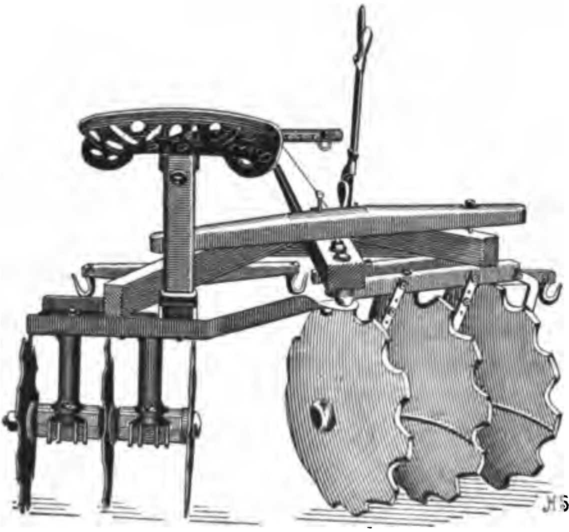

FIG. 2.—Disk plow used for refitting land.

spring plowing is practiced the soil should be harrowed closely behind the plow in order to prevent drying out.

For cutting and pulverizing the soil there is perhaps no tool as serviceable as the disk harrow. There is a type of disk having four gangs, in two sets, one combination in front of the other and so arranged that the soil is first turned to the center and then turned outward again by means of the rear combination. This tool turns the soil twice and leaves it in a level condition. For smoothing and leveling the soil behind the plow a harrow of the type shown in figure 1 is very desirable; this tool not only levels but turns and crushes the soil at the same time.

On land that has been plowed during the autumn and requires replowing in the spring, a device of the type shown in figure 2 will answer and will do the work more rapidly than the plow. This tool is especially adapted to bedding up land that has been previously plowed.

For imparting the final smoothing touch to the soil before planting there is a device consisting of a large number of small disks set in a wooden frame (fig. 3) which does about the same work as a steel rake, but in a rapid manner. A drag or float made from several pieces of scantling nailed together may be used for this purpose, or if the soil is very loose a roller should be run over it. The final leveling should be performed with a tool that will fill and obliterate all tracks or other depressions in the soil, leaving a smooth, even seed bed for either seed sowing or transplanting.

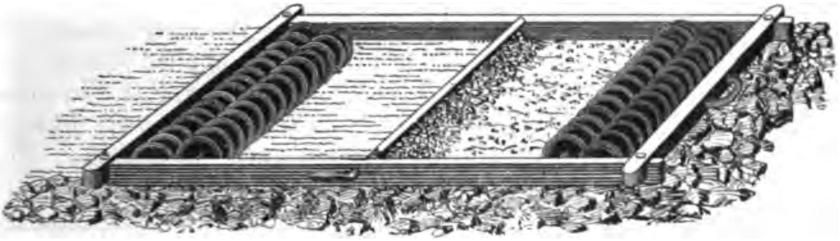

FIG. 3.—Device used for smoothing soil before seeding.

FERTILIZERS.

As the onion is an intensive crop and yields great quantities of marketable bulbs for the area planted, the grower is justified in manuring heavily. It would be difficult indeed to make the soil too rich for onions provided the manures are thoroughly incorporated with the soil. A heavy application of fresh raw manure just before planting would have an injurious effect, but where the manure is well rotted and uniformly applied there is nothing to be feared.

Animal manures.—There is perhaps no fertilizer so well adapted to the production of onions as plenty of clean, well-composted stable manure, and the quantity and frequency of application will depend upon the nature of the land under cultivation. The Bermuda-onion growers of southwestern Texas apply as high as 20 tons of sheep and goat manure to an acre every three years. In addition to the manure there is used 1,000 to 2,000 pounds of cotton-seed meal or commercial fertilizer, and sometimes a top-dressing of nitrate of soda. This sheep and goat manure is from animals that are fed largely upon cotton-seed meal, is saved in the corrals in a climate where there is very little rain, and it contains the essential fertilizing ingredients in very high percentages. The manure is first piled where a little water can be thrown over it and it is composted for several months before spreading on the land. The best results from this manure are not realized until the second or even the third year after its application.

All stable manure used on onion land should be well composted before use and then spread upon the land several months before planting to onions. In the Northern States the manure may be applied during the autumn and well disked into the soil. The land can then be allowed to lie in the rough state and exposed to the action of frost during the winter, or it can be smoothed and seeded to rye, in which case it will be necessary to replow during the early springtime. In the Bermuda district the manure should be applied during the springtime and the land kept frequently stirred during the summer months, with occasional irrigations in order to assimilate the manure and destroy weeds; the planting is not done until the autumn. Another practice in the Bermuda district is to apply fresh manure broadcast at the rate of 10 to 12 tons to the acre during the spring months, then plant to corn and cultivate through the early summer, and add a top-dressing of well-rotted manure after plowing the land for onions in the autumn. This top-dressing should be well worked into the soil by means of disk harrows. Large quantities of fresh manure applied to onion land just before planting will have a tendency to produce an overgrowth of tops at the expense of the bulbs. This is especially true on irrigated lands and soils that are naturally moist.

Commercial fertilizers.—Where there is an abundance of humus matter in the soil the onion crop will be greatly benefited by moderate applications of high-grade commercial fertilizers. A fertilizer that is suited to the growing of potatoes will serve quite well for onions, but the potash should perhaps be supplied in the form of muriate rather than of sulphate. A fertilizer adapted to the growing of onions should contain 4 to 5 per cent of nitrogen, 5 to 7 per cent of phosphoric acid, and 8 to 10 per cent of potash. A fertilizer of this character will cost $38 to $40 a ton and can be profitably applied at the rate of 1,000 pounds to the acre on most soils. Where very intensive culture is practiced it may be profitable to apply as much as a ton to the acre in addition to stable manure.

If it is found desirable to secure the ingredients and mix the fertilizer at home the following materials and proportions are suggested:

No. 1.—For use in the Southern States.

	Pounds.
Nitrate of soda, 14 to 16 per cent nitrogen	200
Cotton-seed meal	750
Superphosphate, 16 per cent	750
Muriate of potash, 50 per cent	300

No. 2.—For use in sections where cotton-seed meal can not readily be obtained.

	Pounds.
Nitrate of soda, 14 to 16 per cent nitrogen	300
Dried blood	500
Superphosphate	800
Muriate of potash, 50 per cent	400

No. 3.—For general use.

	Pounds.
Sulphate of ammonia, 25 per cent	200
Dried blood	300
Cotton-seed meal	300
Superphosphate	800
Muriate of potash, 50 per cent	400

The ingredients of these fertilizers should not be mixed until shortly before they are to be used, as there is danger of loss from chemical action. In mixing, the proper quantity of all ingredients should be weighed and dumped together in a heap on a clean, tight floor. The work of mixing can be done by shoveling over three or four times, but should continue until all lumps are broken and the mass has assumed a uniform color and appearance.

Commercial fertilizers should not be applied until shortly before sowing the seed and should be uniformly distributed and thoroughly worked into the soil. There are one-horse fertilizer distributers that scatter the fertilizer broadcast, but where an amount not exceeding 1,000 pounds of fertilizer to the acre is being used the work of distribution may be performed by means of a common grain drill having a fertilizer attachment. On a small scale the work is generally performed by hand.

Many growers follow the practice of applying only a part of the fertilizer at planting time, reserving the balance to be put on as a top-dressing at some time during the period of cultivation. This plan is especially desirable where onions are grown during the winter, as the application of highly nitrogenous fertilizers in the autumn is liable to promote a soft growth that will be injured by cold. If the fertilizer is not put on until cold weather is over, the crop may be forced without danger of injury. For this purpose only those fertilizers of a very available form will answer. Nitrate of soda is frequently used as a top-dressing during the height of the growing period.

PROPAGATION.

Most of the onions grown in the United States are propagated from seed. Propagation from seed is conducted by three more or less distinct methods: First, by sowing the seed in the rows where the crop is to grow and mature; second, by sowing the seed in specially prepared beds and transplanting the seedlings to the open ground; third, by first growing sets from seed and then, after keeping them through the winter, planting them in the field to produce the crop of mature bulbs. Of these three methods the one first mentioned of seeding in the rows where the crop is to mature is the only one that is practical on a very large scale. Planting sets and transplanting have their advantages, but could not be applied on a large scale owing to the amount of labor required.

Planting the seed.—In the northern onion-growing districts the seed is sown as early in the spring as the soil can be brought to the proper condition. While it is desirable to plant quite early it never pays to sow the seed before the land is in the best possible condition. When the soil has been brought to a smooth, even surface and is fine and mellow, the seed is sown by means of one of the common seed drills, of which there are several makes upon the market. The hand drills which sow one row at a time are extensively employed, but many of the larger growers employ a gang of drills hitched together and plant from five to seven rows at once. A more even distribution of the seed will be secured by the use of the single-row hand drill owing to the closer attention that can be given the one machine. The first row may be planted with a line, and after this the marker on the drill indicates the next row. The drills are so arranged that the shoe and covering blades can be regulated to cover the seed at the proper depth, which will vary with different soils. In heavy or moist soils the depth to cover the seed should not be more than one-half to three-fourths inch, while on loose and sandy soils the seed may be covered an inch or more.

Planting distances and seed required to plant an acre.—Where hand cultivation is practiced throughout, the usual distance between rows is 12 to 16 inches. Where horse culture is employed the distance between rows varies between 24 and 36 inches. The quantity of seed required to plant an acre will depend both upon the distance between rows and the purpose for which the onions are being grown. For the growing of standard market onions in rows 14 inches apart, about 4½ pounds of first-class seed will be required. With the rows 3 feet apart, but 1¼ or 1½ pounds will be necessary. Where it is desired to produce small onions for pickling purposes, the amount of seed may be as great as 25 pounds to an acre. Good seed is essential, and if there is any doubt regarding the vitality of the seed it should be tested before planting by counting and planting four or five hundred seeds in a window box and then determining the germination by counting the seedlings after ten days' or two weeks' time. First-class seed is seldom sold at a low price and good seed at $1.50 or even $2.50 a pound may be cheaper in the end than poor seed at 50 cents. Old and inferior seeds are not only low in percentage of germination, but lack the vitality necessary to produce strong, healthy plants. There are dealers who make a specialty of securing and furnishing extra-quality onion seed, and while their prices are often somewhat above the general market the seed furnished by them is always preferable to ordinary seed.

Thinning.—Experienced growers are frequently able by using extreme care in regulating the drills to distribute onion seed in rows where the crop is to mature so that little thinning will be necessary. Thinning is generally left until the time of the first hand weeding, when all thick bunches along the rows are thinned to a uniform stand of eight or ten plants to the foot. It is always well, however, to allow for considerable loss of plants, and unless the plants are so thick as to actually crowd, thinning will not be necessary.

Transplanting method of growing onions.—The transplanting process, often spoken of as the "new onion culture," is merely a modification of the regular seeding method. The objects gained by transplanting are an earlier crop, a uniform stand, and bulbs of more regular size. Practically the entire Bermuda crop of the Southern States is handled in this manner. Where a small area is to be grown, the transplanting process is the ideal method, but for large acreages and where labor is difficult to obtain this would not be practical. After transplanting, the seedlings will require rain or watering in order that they may start, and for this reason the transplanting process is practically limited to areas where some form of irrigation is available.

In growing onions by the transplanting method the seed is sown in greenhouses, hotbeds, cold frames, or specially prepared beds at the rate of 3½ or 4 pounds for each acre to be planted. Onion seedlings are now being grown in great quantities by southern plant growers and are shipped to northern onion growers. When the seedlings are grown under cover, they are given the necessary attention regarding watering and ventilation and kept growing quite rapidly until near the time for setting them in the open ground. As planting time approaches, the seedlings are "hardened" or prepared for transplanting by increased ventilation and exposure and by withholding water. When ready to transplant, the seedlings should be somewhat smaller than a lead pencil and rather stocky. The plants are lifted from the seed bed and the roots and tops both trimmed somewhat, as shown in figure 4. They are then packed neatly in shallow boxes for removal to the field where they are to be planted.

Various methods are employed for handling the plants in setting. As a rule, a line is used and the land marked to indicate the location of rows. Several methods are employed for marking the distance between plants in the rows; one method is by means of a line with small lead or brass indicators at regular intervals; another method is by means of a board having notches or holes in which a pointed dibble is thrust to form a hole in which to set the plant. A marking device much used by the Bermuda-onion growers in Texas consists of a sectional roller with the sections the same distance apart as the distance between the rows and each section provided with conical pins to form the holes in which the plants are set. The objection to the sectional roller marker is that it can not easily be drawn in a straight line and straight rows are essential to good cultivation.

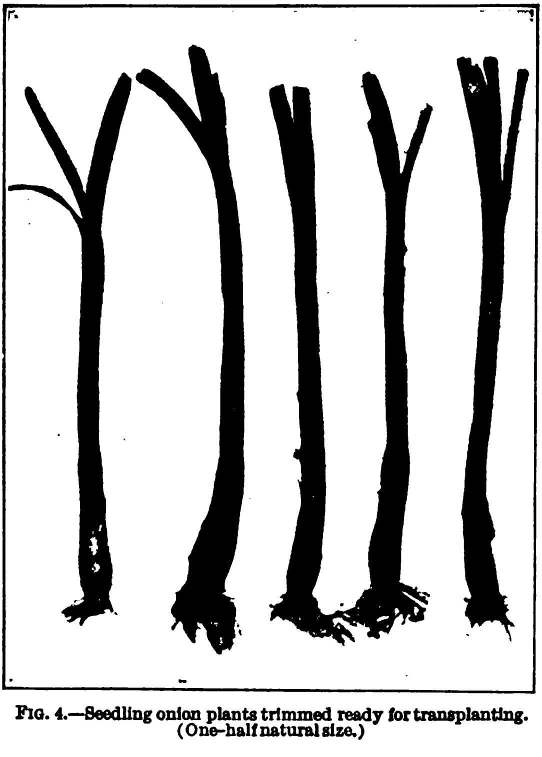

FIG. 4.—Seedling onion plants trimmed ready for transplanting. (One-half natural size.)

After marking the land, the plants are dropped ahead of the planters, or they may be kept in the trays and simply removed as planted. The transplanting process consists mainly in pushing the root end of the seedling into the soil with one finger and then firming the soil about the plant. This work is very laborious and can only be performed economically by very cheap labor. A small plow, such as is generally included with the attachments of the wheel hoe (fig. 5), is often employed for opening a furrow in which to set the small onion plants. As the plants are set the soil is either drawn about them by hand, or the plow may again be used for this purpose. In the Bermuda-onion district the work of transplanting costs from $15 to $25 an acre and is performed by laborers who are content with 50 or 60 cents a day, boarding themselves. The work of transplanting is as a rule done by contract at about $1.50 for each bed of one-tenth acre. In transplanting, all inferior plants should be rejected, thus insuring a more perfect stand and development.

Propagation by sets.—The use of sets is still another modification of the regular seedling method, in which the seed is planted one year to form the sets from which to grow a crop of mature onions the following year. Like the transplanting process the use of sets is limited in its application. Onions grown from sets will ripen earlier than those from seed sown in the field, but the use of sets for commercial onion growing is not so practical as transplanting seedlings. In planting onion sets a furrow about 2 inches deep is opened, the sets being dropped about 3 inches apart and firmly covered. For best results the sets should be placed in an upright position. The quantity of sets required to plant an acre will depend upon their individual size and planting distances, but it is generally between 15 and 20 bushels.

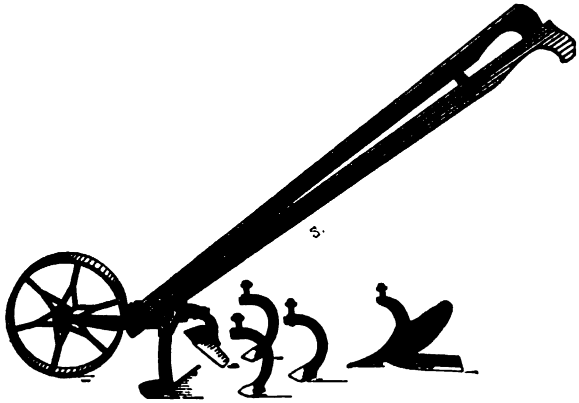

FIG. 5.—Wheel hoe adapted to working onions.

METHODS OF TILLAGE.

The cultural requirements of the onion are frequent shallow stirring of the soil and freedom from weeds. The feeding roots of the onion run close to the surface of the soil and should not be disturbed by deep cultivation. Sometimes a heavy rain immediately after seeding will so pack the surface that the seedlings can not break through. Under such circumstances it will be necessary to slightly break the surface by means of a steel rake or a rake-like attachment on a cultivator. As soon as the plants are up and the rows can be followed the cultivator should be started to loosen the soil, which is always more or less compacted during seeding.

Hand cultivation.—Where the rows are 14 inches or less apart, the work of caring for the crop must all be done by hand. For this purpose the wheel-hoe tools of various types are essential. These implements are provided with several kinds of hoes, cutters, and sweeps designed to work the soil away from the plants, to shave the surface and destroy weeds, and to stir the soil and work it back around the plants. Onions grown on muck and alluvial soils will require from eight to fourteen workings with the wheel-hoe implements; on sandy soils it will not be necessary to cultivate so frequently.

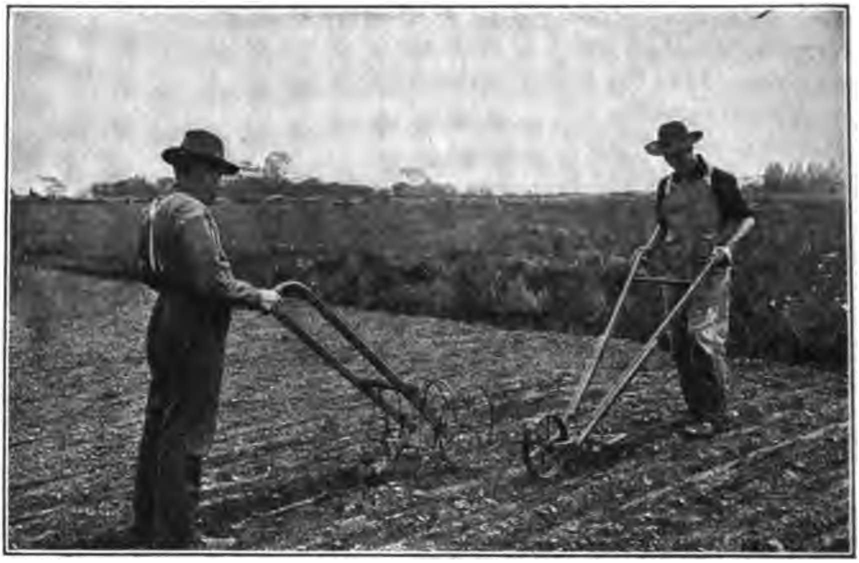

FIG. 6.—Special wheel hoes for cultivating onions.

Several types of wheel hoe are in use, but those having a single wheel and passing between the rows are most desirable. Those of the type in figure 5 are good. Many growers have designed special implements to suit the requirements of their soils; two of these are shown in figure 6, the one designed to cut the soil away from the row and the other to stir and work the soil back to the row. Some of the growers in the onion fields near Chicago have

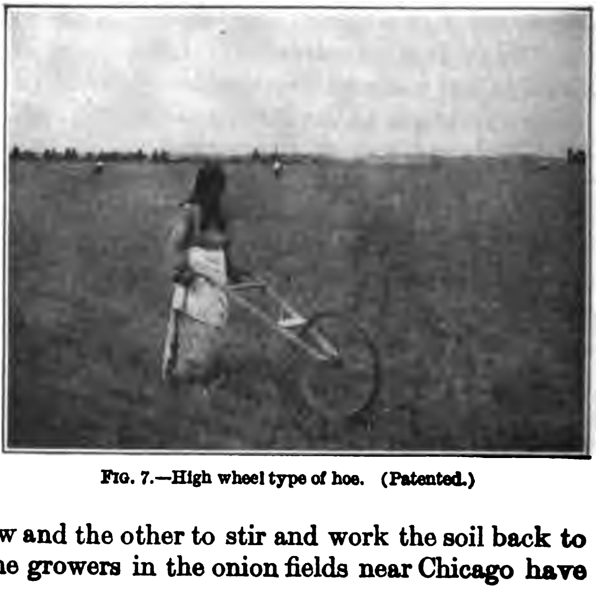

FIG. 7.—High wheel type of hoe. (Patented.)

adopted a hoe-stock consisting of a pair of light plow handles, an iron stock, and the front wheel of a bicycle. To the stock of this device may be attached almost any form of sweep or cutter, and the implement is exceptionally easy to propel. The wide distance between the handles places the implement well under the control of the operator. Figure 7 will give an idea of the general appearance of this implement.

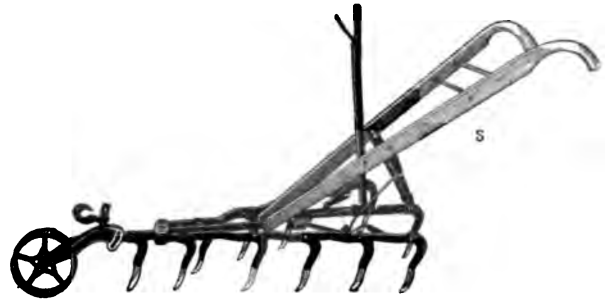

FIG. 8.—Small-tooth horse cultivator.

Horse cultivation.—In sections where onions are grown on a soil that is not well adapted to hand culture the rows are placed 30 to 36 inches apart and the cultivation is performed by means of horse-drawn tools. This is particularly true where onions are grown on the "black waxy" soils of Texas and other soils of the prairie type. As with hand culture, frequent shallow stirring of the soil is essential, the work generally being performed with one of the harrow-tooth cultivators. Those of the type shown in figure 8 are well adapted to this work. An implement known as a weeder can be used for breaking the surface before the seedlings appear; also for general cultivation by removing a tooth at the point where the rows are located.

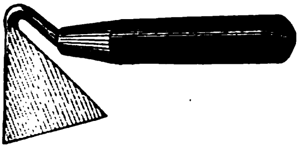

FIG. 9.—Onion hoe.

Hand weeding.—It is well-nigh impossible to produce a crop of onions without some hand weeding. During favorable seasons the strictly hand work may be reduced to but one or two weedings, but a greater number will be necessary during rainy seasons. Each hand weeding will cost from $5 to $12 an acre, according to wages paid and the number of weeds present. The work of hand weeding may be facilitated by the use of some of the small hand tools designed for the purpose. Among these tools might be mentioned the onion hoe, figure 9, the hand weeder, shown as figure 10, and the thinning or weeding hook, figure 11. Girls and boys are expert at hand weeding, the practice being to work them in gangs of ten to twenty with an overseer behind them to see that the work is properly done. In some localities the wages paid for this class of work are as high as $1.50 a day.

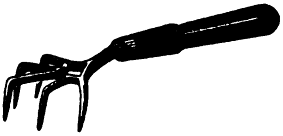

FIG. 10.—Hand weeder.

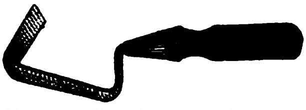

FIG. 11.—Thinning or weeding hook.

IRRIGATION.

Outside of the areas where irrigation methods are depended upon for the production of general crops it is not customary to use artificial watering in the growing of onions. In a few cases the land has been equipped with an overhead sprinkling system which is employed to moisten the soil after the seed is planted and also during extremely dry weather. On peat and muck soils the young seedlings are frequently lost by the dry muck blowing with the high winds of early springtime. In this way a part of the field may have the soil blown off to such an extent that the plants will be left without soil about them, while other portions of the field will be covered by 1 or 2 inches of loose muck. The use of a small quantity of water sprayed over the field will prevent this shifting of the soil during a windstorm, and thus save the crop from destruction. Sandy soils are also subject to the action of winds to a greater or less extent, and losses may be prevented by the timely application of water over the surface. In a few instances subirrigation is employed in the growing of onions.

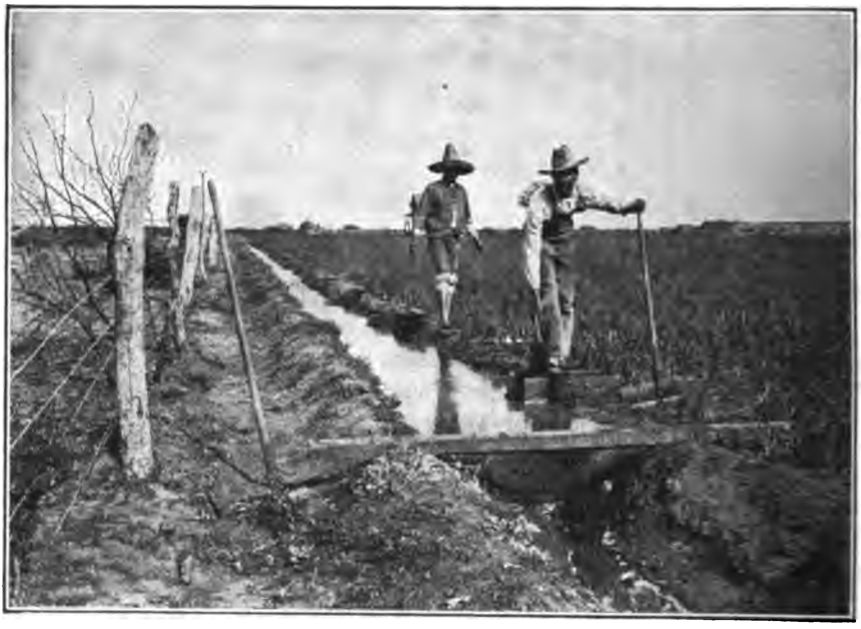

FIG. 12.—Irrigation ditches in Bermuda-onion field in Texas.

Throughout the Bermuda district of the Southwestern States surface irrigation is almost universally employed. The Bermuda onions are planted mostly in comparatively level beds with dividing ridges and are flooded once each week or ten days during the growing period. About a week before the plants are set the soil is flooded and then worked over with disk and smoothing harrows just ahead of the planters. Within a day or two after planting the land is again flooded and the surface water drawn off; this process is repeated, with alternate cultivations, as often as the land becomes dry. Toward the end of the growing season the water is withheld to allow the bulbs to ripen. As a rule about ten waterings in all are required, at a cost of about $1.50 an acre for each watering, or $15 altogether. Figures 12 and 13 will give a good idea of the methods of applying the water in the Bermuda-onion-growing district.

In the principal Bermuda-onion-growing districts the water for irrigation purposes is obtained only after the expenditure of thousands of dollars for pipe lines and pumping machinery, and the cost of watering as given above does not include any share of the original cost for installation.

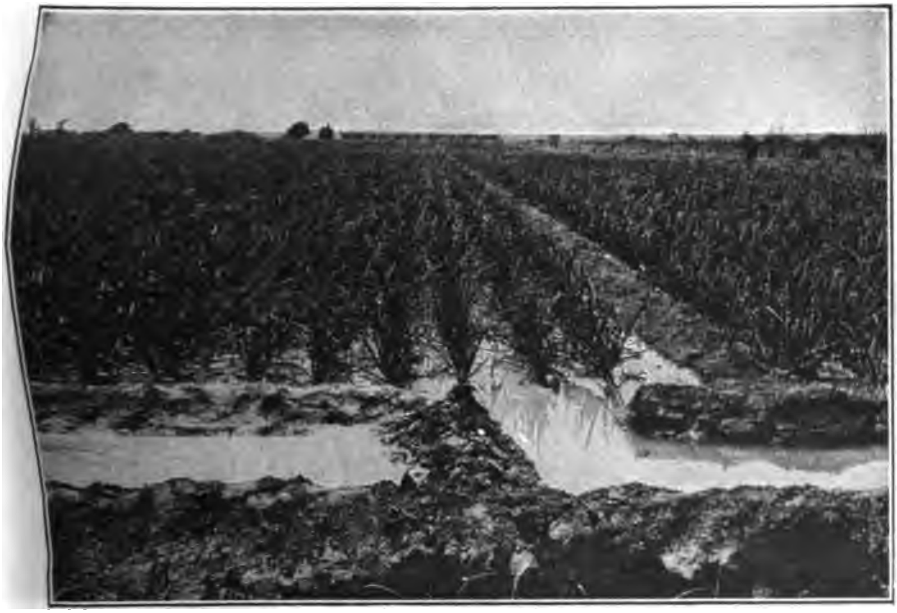

FIG. 13.—Irrigation of Bermuda onions in Texas.

HARVESTING AND CURING.

In the northern onion districts the crop ripens and is harvested during the latter part of the summer and early autumn. As a rule the work of harvesting onions begins late in July and is practically completed and the crop housed before October first. In the Southern States, where the crop is grown during the winter, the harvesting and marketing period is during the spring months and is practically ended before the northern product comes upon the market.

Condition of bulbs when ready to harvest.—In the North the bulbs are allowed to become as ripe as possible before removing them from the soil. Growers prefer that the tops ripen down and shrivel and that the outer skin of the bulbs be dry before they are pulled. Figure 14 shows a field of onions in prime condition for gathering. To the southward, where the onions are not cured so thoroughly, they are often pulled about the time that the tops begin to break and fall. The ripening process may often be hastened by rolling a very light roller or a barrel over the tops to break them down. This process is frequently spoken of as "barreling."

Methods of handling the bulbs.—Where the bulbs are practically upon the surface they may be pulled by hand and thrown in windrows consisting of eight or ten onion rows. If the onion bulbs are considerably covered with soil it will be necessary to employ a one-horse plow or a cultivator with a sweep attached for lifting them. In any case it will be necessary to gather them from the soil by hand. After lying in the windrows for several days and being stirred occasionally with wooden rakes they are gone over and the tops removed either by twisting or cutting with ordinary sheep shears. In cases where very bright color is important, as with fancy White Globe onions, and this would be injured by exposure to the sun and rain, the bulbs are cured in long, narrow, low ricks formed by two

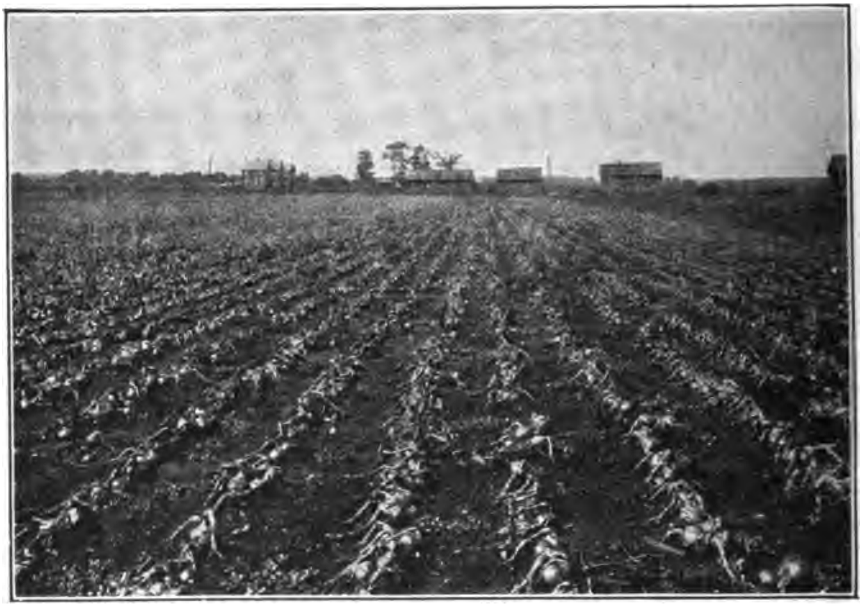

FIG. 14.—Field of onions in condition for gathering.

rows of onions laid with the bulbs regularly to the center, tops to the outside, the rows a few inches apart at the bottom of the rick but coming together at the top, and the top of the rick covered by straw or boards to shed the rain. As the tops are removed the bulbs are generally placed in crates for drying. In some sections onion-topping machines are employed, the bulbs being hauled from the field to a central location and run through the topper. These machines remove the tops, grade the bulbs, and deliver them into the crates or bags. If crates are not employed for curing, the bulbs are allowed to lie in the windrows for some time, and are then either put into sacks or hauled to slat cribs, where they complete the curing process. Too long exposure to hot sunshine will injure the bulbs.

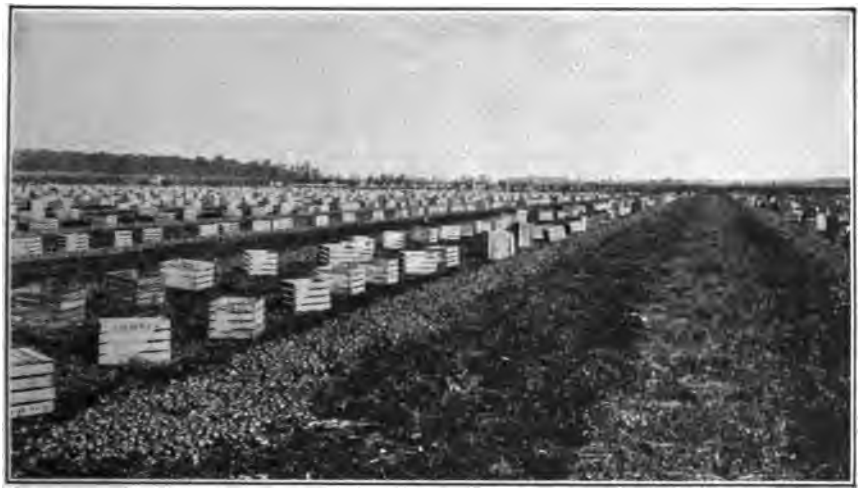

FIG. 15.—Onions drying in windrows, showing crates used for curing and storing.

Figure 15 shows a field of onions drying in windrows, with crates ready for their removal from the field.

After gathering into crates the crates are either stacked in the field, hauled to a central stacking yard, where the stacks of crates are covered with boards or canvas, or hauled to open sheds and there piled one upon the other with numerous air spaces until the onions are thoroughly cured.

Where the bulbs are extremely dry at the time of their removal from the soil, they may be allowed to lie in the windrows for a few days only, and then sorted and cleaned in the field ready for packing and marketing. Where onions are put into sacks and afterwards allowed to remain in the field, the sacks should be supported on poles laid upon the ground, as shown in figure 16.

In the Bermuda-onion districts, where very little attention is given to the curing of the crop, it is the practice to pack and load into the cars as soon as possible after pulling and topping. When the shipping is at its height, it is not uncommon for onions that are pulled from the soil in the morning to be in the cars and on their way to market by evening; however, a portion of the crop is given a more thorough curing process, and the entire crop would be benefited by at least two days of curing before shipment.

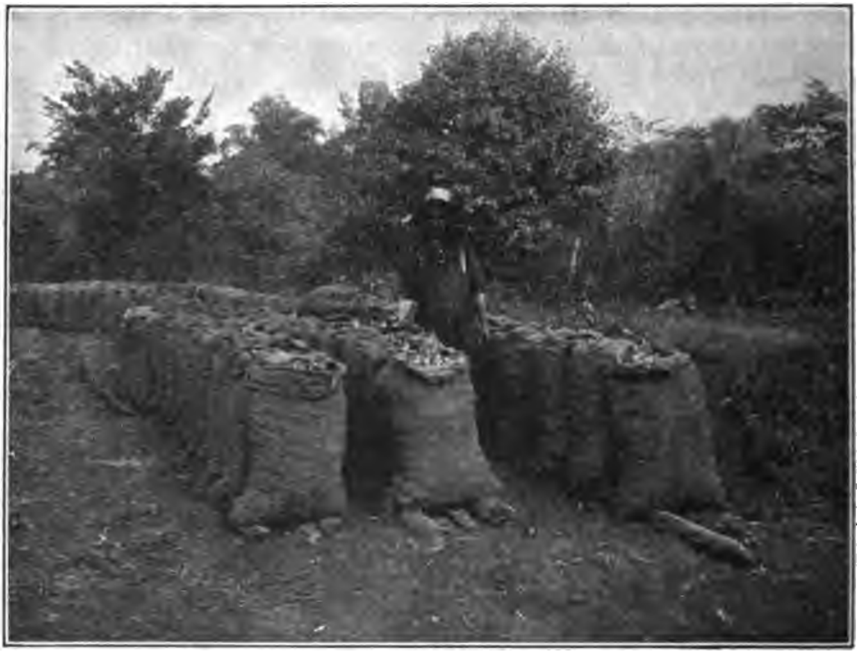

FIG. 16.—Method of curing onions in sacks standing in field.

STORAGE.

In order that onions should keep well when stored they must be well ripened and thoroughly cured. Those that are immature, soft, or "thick necks" should never be placed in storage but sold as soon as gathered for whatever price they will bring. Good storage onions will rattle almost like blocks of wood when poured from one crate to another. In order that the bulbs may remain bright and of attractive appearance they should not be allowed to lie exposed to the weather, but should be hauled and stored in open sheds just as soon as they may safely be placed in one-bushel crates.

After the bulbs have remained in drying sheds or cribs for several weeks they will be ready for screening and removal to the storehouse. In handling onions it is the rule to pass them over a screen each time they are moved, as in this way the loose skins are removed and any soft or decaying bulbs may be sorted out. When bags are used for drying in the field, the onions are screened in the manner shown in figure 17, and the bags refilled for hauling to the storage house.

In screening, the onions are placed on one end of the screen while the men stand alongside and stir the bulbs about with their hands, passing them along to the opposite end, where the bags are filled.

Conditions required in storage.—The essentials for the successful storage of onions are plenty of ventilation, storing in small quantities, a comparatively low temperature, dryness, and safety from actual freezing. Any building wherein the above conditions may be secured will answer, but houses of the type shown in figure 18, which are built especially for the purpose, are most satisfactory.

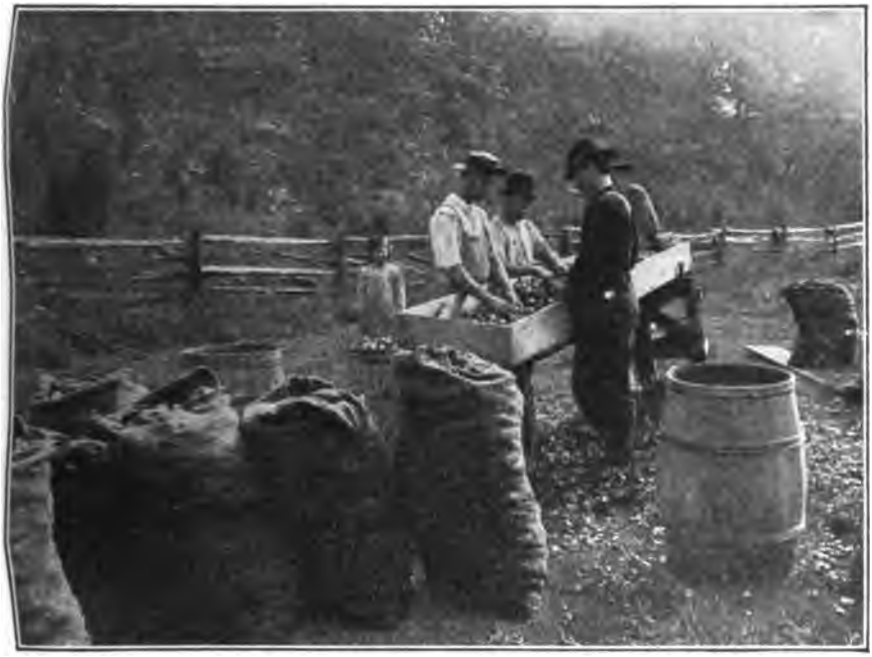

FIG. 17.—Grading onions in the field by means of a screen.

The construction of the storage house should be double throughout, with plenty of felt or paper lining. Both top and bottom ventilation should be provided and the ventilator openings should have doors that may be closed to control the temperature. The floors are constructed of narrow planks with half-inch spaces between the planks for the passage of air. Bottom ventilation is frequently secured by means of drain pipes built into the foundation at the surface of the ground. These pipes are carried some distance toward the center of the house and discharge the cool air at a point where it is most needed.

The temperature of the storage house should be carried as low as possible without actual freezing. During extremely cold weather the ventilator openings and doors should be kept closed to keep out cold, and after the onions have become thoroughly chilled the house should be kept closed in order to hold the temperature down and prevent the entrance of moisture during warm or rainy periods. Damp, foggy weather is injurious to onions, especially if it follows a period of cold, and will cause the bulbs to become covered with moisture if the outside air is admitted. A little artificial heat from a stove or radiator may be required during excessively cold weather, but so long as the temperature in the house does not fall below 30° F. there will be no danger of injury. A temperature of 32° to 34° will give good results.

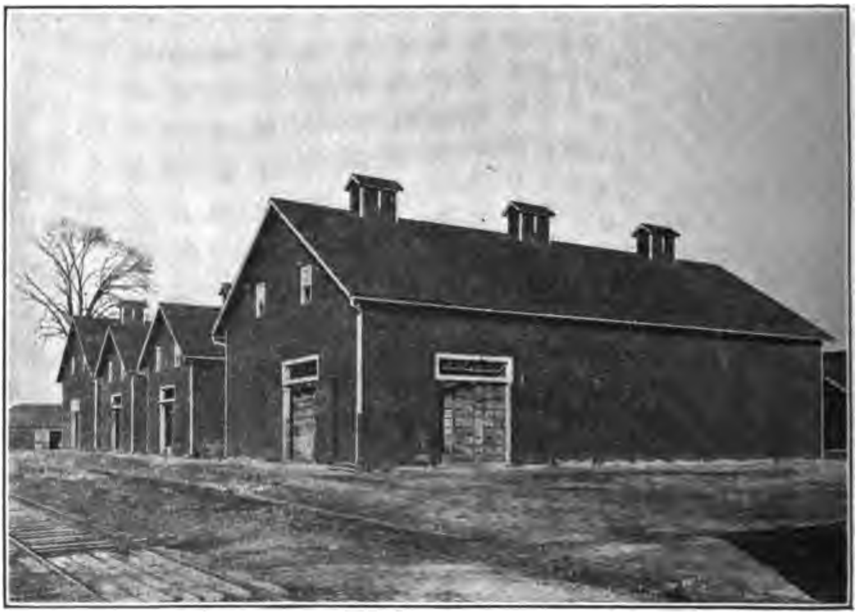

FIG. 18.—Onion storehouses.

Methods of storing.—The best method of storing onions is in standard size slat crates 20 inches long, 16 inches wide, and 14 inches deep, outside measurements. The material for the sides and bottom is about $\frac{3}{8}$ inch thick and $2\frac{1}{2}$ inches wide, four pieces being used to form a side. The corners are reinforced on the inside by means of three-cornered pieces of oak, to which the slats are nailed. These dimensions provide crates that are interchangeable, the width of five being equal to the length of four. These crates will also nest together when empty, with one inside of two turned together. The full crates are stacked in the storehouse with 1 by 3 inch strips between them to allow for the circulation of air, as shown in figure 19.

Onions are sometimes stored in slat bins holding 100 to 300 bushels each. Bags are also used to some extent, but neither bags nor bins are as satisfactory as the crates, owing to the difficulty in providing the necessary ventilation and change of air through the onions. Bulbs stored in bags or bins must be more thoroughly cured than those stored in crates. There are single large storehouses in use that will accommodate 50,000 to 60,000 bushels of onions when stored in crates.

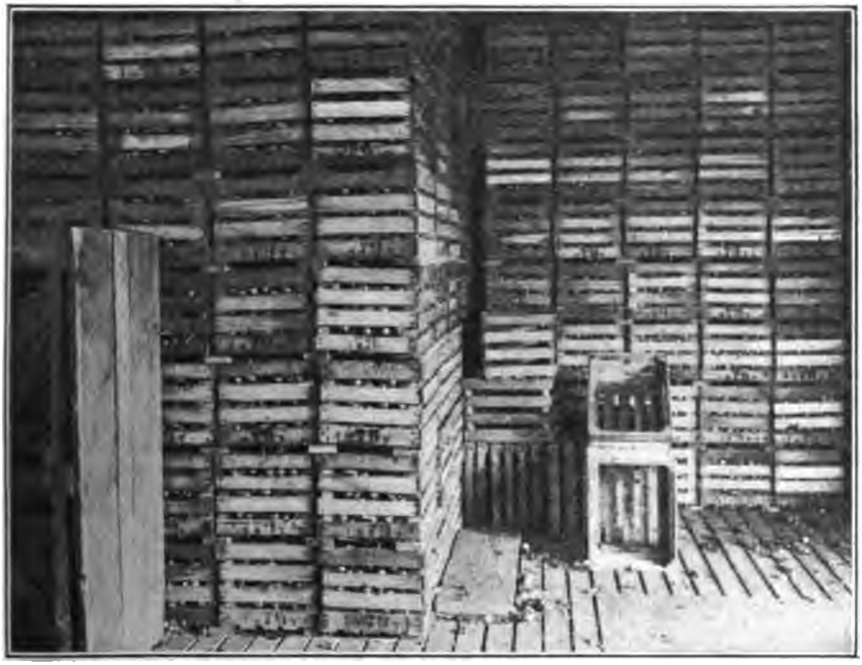

FIG. 19.—Inside of storage house, showing method of stacking crates.

MARKETING.

Large quantities of onions are sold and shipped direct from the fields where they are grown. A part of the crop is held in temporary storage until late autumn or early winter. During recent years the winter storage of onions has become of great importance and the finest stock is held for late winter deliveries. The Bermuda crop from the southwestern part of the country comes upon the market during April and May, so that most of the storage onions are disposed of before that time.

Grading.—In marketing onions the first essential is to properly grade and clean the bulbs, in order that they may present an attractive appearance when offered for sale. Ordinarily the bulbs are separated into three grades—primes, seconds, and "picklers." The primes include all those of 1¼ inches in diameter and larger, and the seconds consist of those from ¾ inch to 1¼ inches in diameter, while all those that will pass through a ¾-inch screen are sold for pickling purposes. The grading is generally done in the field during the cleaning process, but as onions shrink considerably while in storage it is necessary to regrade before placing upon the market. The type of screen used for grading onions is shown in figure 20. For cleaning the pickling onions an ordinary fanning mill is employed, special screens being provided for the purpose.

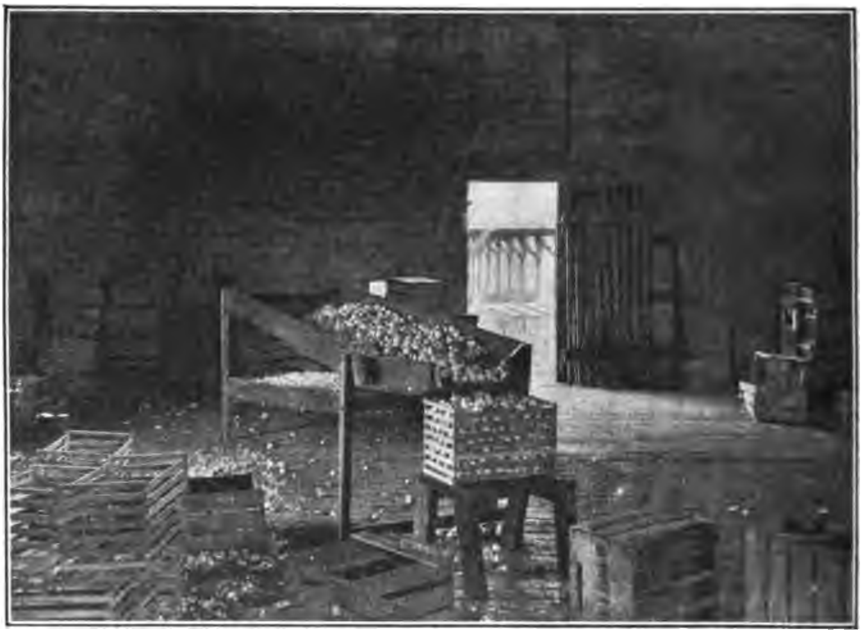

FIG. 20.—Screen used for grading and cleaning onions, showing folding crates largely used for marketing.

Shipping packages.—Onions are placed upon the market in crates, bags, barrels, Delaware baskets, one-half barrel baskets, and in bulk. The folding crate, shown in the foreground of figure 20, is undoubtedly the most attractive package in use for marketing onions. The bags employed are of special open-mesh weave and hold 100 pounds. Onions are sometimes shipped loosely in cars and shoveled into barrels or bags at their destination.

Weight of onions.—The legal weight of onions per bushel varies somewhat in different States, but 56 pounds of dry onions are generally considered a standard bushel.

IMPORTANT COMMERCIAL VARIETIES OF ONIONS.

Common market varieties.—The varieties of onions that have distinctively yellow, white, and red skins and are of the globular type are of greatest commercial importance. Among the varieties that belong to the yellow globe class are the Prizetaker, Yellow Danvers, Yellow Globe Danvers, Southport Yellow Globe, and Ohio Yellow Globe. The principal white varieties are Southport White Globe, New Queen, Italian Tripoli, Silver Skin, and White Silver King. Among the more important red sorts are Red Globe, Red Wethersfield, and Australian Brown.

The principal Bermuda varieties are Red Bermuda, White Bermuda, and Crystal Wax. The Bermuda onions are all of the more or less flat type. The red coloration of the Bermuda onion is not distinctive like that of the Red Wethersfield or Red Globe varieties, but is lighter in color. The famous Valencia onion is of the Prizetaker type, is light yellow in color, grows to a large size, and is mild in flavor.

In the selection of varieties for any particular locality the soil conditions and market requirements should both be considered. Those adapted to the muck soils are the yellow and red sorts. For alluvial and prairie soils the red and brown varieties are to be preferred, while all kinds do well on the sandy loams and light soils. A cleaner, better grade of white onions can generally be produced on light or sandy soils than on muck or clay loams. Those of the Bermuda, Spanish, and Egyptian types flourish on the deep, rich alluvial soils of the river bottoms and delta regions.

Certain of our markets show a decided preference for onions belonging to a particular type. The red and brown varieties find ready sale on the markets of the Middle West, while onions of the yellow and white varieties are preferred in the eastern cities. Onions will withstand long-distance shipment, those of the Red Globe type being generally more subject to injury than the yellow and brown sorts. Some of the white varieties also have a thin skin and are easily injured. It should be the aim of every grower to employ varieties that will withstand handling and at the same time find ready sale on the market.

Other types of onions.—Among the types not already discussed are top onions, multipliers, garlic, and leeks, which are planted to some extent for marketing purposes.

The top or tree onion, which reproduces by means of small bulblets formed on the top of a seed stalk, is extensively used in the production of early spring bunching onions.

The multiplier or potato onion reproduces by a division of the bulbs. In growing this variety it is necessary to plant large bulbs to produce sets for the next year's planting and small bulbs or sets for the crop of large onions. The bulbs of this variety may remain in the soil year after year and are desirable for use early in the springtime.

Garlic is closely allied to the onion, but will remain in the ground from one year to another if undisturbed. Garlic is planted by setting the small bulbs, or cloves, in either the autumn or early spring. The culture is practically the same as for the onion.

The leek also belongs to the same class as does the onion, but requires somewhat different treatment. The seed is usually sown in a trench and the plants thinned to about 4 inches in the row. The plants of the leek are given about the same cultivation as onions, except that after they have attained almost full size the soil is drawn around them to a height of 6 or 8 inches to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored in cellars for winter use.

THE PRODUCTION OF BERMUDA ONIONS.

Bermuda onions are now an important commercial crop in Texas, California, and Louisiana, with small plantings in a number of the Southern States. The Bermuda onion fields of Texas are located around Laredo and other points in the Rio Grande valley. In 1926 Texas shipped 4,032 carloads from 12,510 acres, California 1,790 carloads from 2,750 acres, and Louisiana 588 carloads from 2,300 acres.

SOILS AND CLIMATE ADAPTED TO THE BERMUDA ONION.

Soils of a silty or alluvial nature are suited to the production of Bermuda onions, and those containing considerable sand are most desirable. As already noted in referring to fertilizers for onions, the Bermuda requires a very rich soil for the best results, and this can only be obtained by first selecting a good soil and then manuring heavily. The Bermuda onion as grown in this country is a winter crop; therefore, mild climatic conditions are required. While the plants would withstand considerable freezing, their growth is seriously checked by cold weather, and the crop will not mature in time for the early market if grown to the northward.

CULTURAL METHODS.

The cultural methods employed in the growing of Bermuda onions are essentially the same as those for ordinary onions. As the greater portion of the crop is grown in a region which has no regular rainfall, irrigation methods are employed almost universally. The greater part of the crop is grown by the transplanting process and a great amount of hand labor is required. The seeds are sown in specially prepared outdoor beds from the middle of September to the middle of October, and the seedlings are transplanted to the field November 20 to January 10, or even later. Three and one-half to four and one-half pounds of seed are required for each acre to be planted; this will allow for discarding all the weaker plants. The plants are allowed to remain in the seed bed until they are from $\frac{3}{16}$ to $\frac{1}{4}$ inch in diameter before they are transplanted. As the seedlings are lifted the greater portion of both the small roots and the tops is trimmed off in order that they may be transplanted more readily. (See fig. 4.)

HARVESTING AND MARKETING.

Bermuda onions are harvested as early as possible, generally before the tops have become fully ripened. For removing the bulbs from the ground a 1-horse plow, a potato digger, or a cultivator with a cutter wing attached is employed. The bulbs are then separated from the soil by hand, the tops cut off with shears, and the onions thrown in windrows or piles to dry in practically the same manner as for the regular-crop onions in the North. After the bulbs have become thoroughly dry on the surface they are either placed directly in the crates for shipment or are carried to a packing shed to be graded and packed for market.

During the early days of the Bermuda-onion industry the crop was shipped largely in bags, but it was soon found that the bulbs were too perishable for this method of handling. At present the greater portion of the crop is sent to market in folding slat crates that are about 20 inches long, 12 inches wide, and 12 inches high.

These crates hold approximately 50 pounds of onions and weigh 56 or 57 pounds when filled. The cost of these crates is about $18 a hundred, but they add enough to the attractiveness and carrying qualities of the onions to make their use profitable.

YIELD OF BERMUDA ONIONS AND PRICES OBTAINED.

Phenomenal yields of 34,000 and 35,000 pounds of Bermuda onions are frequently made on an acre of land, but this is far above the general average, which is in the neighborhood of 10,000 or 12,000 pounds to the acre. Many fields, especially when planted for the

first time, do not yield as much as 10,000 pounds to the acre. On land that has been heavily manured and planted to onions for several years the yield averages about 16,000 pounds.

The prices paid the growers vary according to the market and condition of the crop, but are generally about $1.60 a hundredweight, the buyer furnishing the crates and loading the cars. With a normal yield of 16,000 pounds the returns would at this rate be about $250 an acre.

In figuring cost of production the following items should be included: Interest on investment in land and equipment; depreciation of equipment; preparation of land; manure and fertilizers; cost of seed; cost of growing the plants; transplanting from plant bed to field; cultivation and hand weeding; irrigation; harvesting, drying, and preparing onions for market.

The best Bermuda-onion farms are valued at $300 to $500 an acre. In order to prove profitable, the growing of Bermuda onions should be conducted on a comparatively large scale. The necessary land and irrigation facilities will require the initial outlay of from $10,000 to $30,000, and the running expenses are quite heavy. Labor can be secured at a low price, but is correspondingly inefficient and often not to be had in sufficient quantities. Furthermore, the markets are now pretty well supplied with Bermuda onions, and persons who desire to engage in their production are advised to investigate every phase of the industry before embarking too heavily in it. The expansion of the Bermuda-onion industry is limited by the facts that a large supply of bulbs can be grown on a comparatively small area, that the distance to market is great, that the product is perishable, and that the markets will consume only a limited quantity at the prices at which the crop can be sold with profit.

GREEN ONIONS FOR BUNCHING.

Another phase of onion culture that is of considerable importance in certain localities is the production of young bunching onions for the early spring trade. In several sections along the South Atlantic coast the growing of this class of onions is quite an enterprise. Many persons who are engaged in other lines of work follow the practice of growing a small area of bunching onions as a side issue.

TYPE OF ONIONS EMPLOYED.

The varieties known as multipliers and top onions are generally employed for this purpose; however, bunching onions are sometimes grown from ordinary sets, from inferior and damaged large onions, and from seed. The multipliers and top onions are the only kinds adapted for this work on a large scale.

CULTURAL METHODS.

For growing bunching onions the bulbs or sets are planted during the autumn either in beds or in rows 12 or 14 inches apart with the bulbs quite close in the rows. The bulbs will start growing within a short time and make more or less growth during the winter. As soon as the weather becomes warm during the first months of spring the onions make a rapid growth and are ready for marketing about the time peach trees begin to bloom.

The land upon which these onions are grown should be rich and mellow, but very little actual cultivation will be required. Where the winters are severe it may be necessary to provide slight protection, either a little straw, loose manure, leaves, pine straw, or corn fodder that has been run through a shredder. If the onion beds are protected on the exposed sides by means of a wind-break consisting of a grove of pines, a fence of boards, pine boughs, or corn fodder, the crop will be ready for marketing a little earlier than if left exposed. The onions not gathered for marketing are allowed to remain to form the bulbs for planting the following season.

MARKETING.

In marketing this class of onions the young shoots are pulled, the roots trimmed, and the outside peeled off, leaving the stem white and clean. The onions are then tied in small bunches by means of a soft white string, the tops trimmed slightly, and the bunches packed in crates or baskets for shipment or sale on the local market. This phase of the onion industry is limited to small plantings and is well suited to the needs of the general market garden.

During the springtime and early summer large quantities of ordinary young onions are pulled when the bulb is about the size of a fifty-cent piece, the roots and tops are trimmed, and they are then bunched and sold for stewing purposes. So far as known, this class of onions is not shipped to any great extent, but is sold mainly on local markets.

ENEMIES OF THE ONION.

The onion crop of the United States is by no means free from both disease and insect enemies. For information regarding them and measures of control, the reader is referred to the following publications which may be obtained on application to the United States Department of Agriculture, Washington, D. C.:

Farmers' Bulletin 1060, Onion Diseases and Their Control.

Farmers' Bulletin 1371, Diseases and Insects of Garden Vegetables.

SUMMARY.

Onions are one of the most common garden crops and are adapted for planting under a wide range of soil and climatic conditions. The intensive type of culture employed in producing onions makes the crop one of the best for growing in small patches and in home gardens.

Commercial onion culture is also profitable on a large scale where soil, climatic, and marketing conditions are suitable. Many of the large muck-soil deposits of the Northeastern States, especially in the region adjacent to the Great Lakes, are well adapted for the commercial growing of onions. The loamy soils of the Connecticut River valley are also well suited for growing the crop.

Owing to variations in the cost of labor, tools, fertilizers, seed, and other materials and the many factors involved in the production of an onion crop it is impossible to give definite cost and profit figures. The average yield of onions is around 290 bushels to the acre, but yields of 400 to 600 bushels are not uncommon. The price of onions is extremely variable one year with another, but on the whole the crop has proved profitable to the growers when taken on an average for a period of years.

In some sections onions are grown in rows 3 feet apart and given horse cultivation, thus reducing the yield to about 150 bushels on an acre and cutting down production costs in proportion. This method of growing onions is especially adapted for use on low-priced land and where hand labor is scarce.

PRESENT RELATION BETWEEN SUPPLY AND DEMAND.

Both the supply and the demand for onions are increasing and at present bear about an equal relation to each other. Some years the supply falls a little short and the prices go somewhat higher, with the result that larger quantities are imported. The following season the plantings are generally heavier, the market may be a little slow, and the result will be low prices and a great many people will discontinue the growing of onions.

Prices of onions, especially the Texas-grown Bermuda onions, are greatly influenced by importations of Egyptian onions which appear on our markets about the same time of the year that the Bermuda onions are being marketed. The ease with which both the Egyptian and the Spanish onions can be delivered to our eastern markets as compared with the long freight haul from southwestern Texas or Pacific Coast States renders the position of the American Bermuda onion grower more or less hazardous. Despite this condition, however, both the Bermuda and the Spanish onion industries have become well established in the United States. The American grower of Bermuda onions is still dependent upon the Teneriffe Islands for his seed supply. In the case of the Valencia or Spanish onion, a part of the crop is grown from imported seed, but American seedsmen are now providing the remainder of the seed supply.

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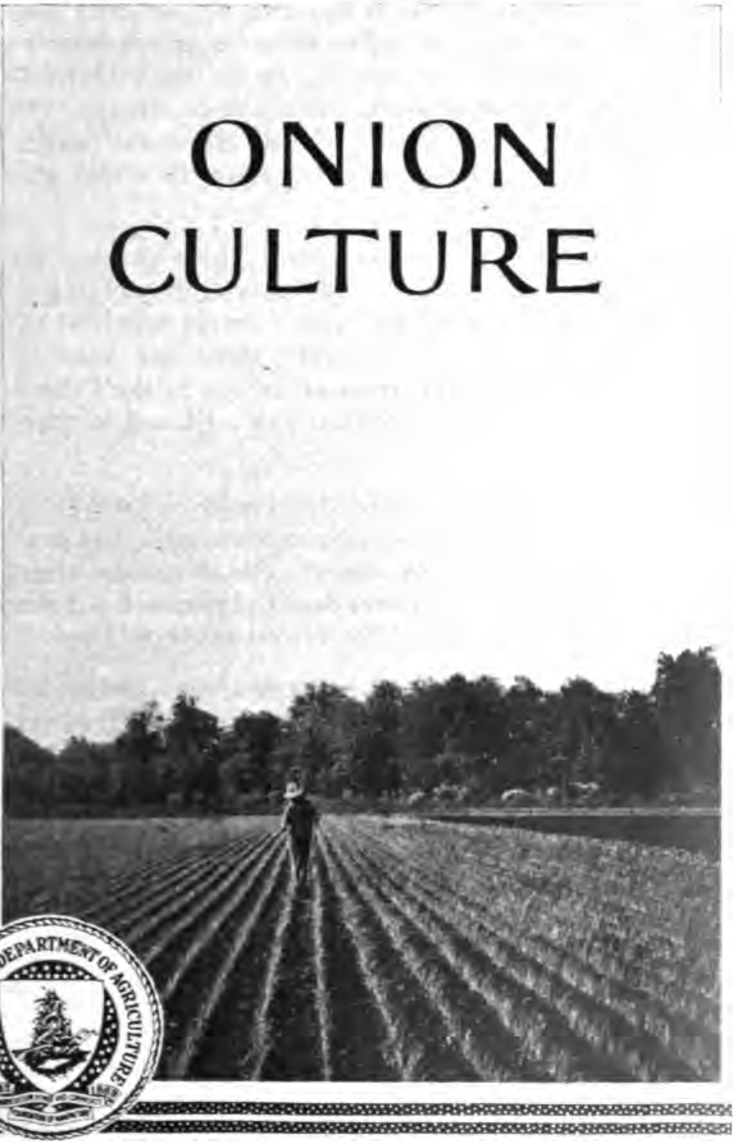
FARMERS' BULLETIN No. 354

ONION CULTURE



THE ONION, in one or more of its several forms, has been in use throughout all time of which we have authentic history. It is of Old World origin, but was brought to North America by the early discoverers and colonists. The onion is grown universally in home gardens and is one of our important market-garden and truck crops. It is adapted for growing on a wide range of soil types and under varying climatic conditions, but requires a rich soil and plenty of moisture.

Onions are an intensive crop, their production involving considerable hand labor, but yielding a relatively high return per acre. Prices received by the growers vary considerably from one year to another, but the production of onions in the United States is fairly well stabilized and adjusted to market demands.

Recently there has been developed in several of the Western States a specialized industry in the production of the Valencia onion. The Bermuda-onion industry of southern Texas and California has been expanded and extended to several other sections.

The production and shipment of large numbers of early seedling onion plants by southern plant growers has to a certain degree replaced the use of onion sets for planting in home gardens and for a portion of the northern early market crop.

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ONION CULTURE

By W. R. BEATTIE, *Senior Horticulturist, Office of Horticultural Crops and Diseases, Bureau of Plant Industry*

CONTENTS

Page
Introduction 1
Climatic requirements 2
Soils adapted to onion culture 3
Cultural methods 4
  Preparation of new land 4
  Crop rotation 4
  Preparation of the soil 5
  Fertilizers 6
  Planting 8
  Cultivation 11
  Irrigation 13
Harvesting and curing 14
Storage 17
Marketing 20
Page
Commercial varieties 21
Production of Bermuda onions 22
  Soils and climate adapted to the Bermuda onion 22
  Cultural methods 23
  Harvesting and marketing 23
  Yield of Bermuda onions and prices obtained 23
Green onions for bunching 24
  Cultural methods 24
  Marketing 24
Diseases of the onion 25
Onion insects 25
Present status of the onion industry 26

INTRODUCTION

THE ONION is one of the important market-garden and truck crops in the United States and is very generally grown in home gardens. It thrives best on alluvial and drained muck soils under a temperate climate, but may be grown under a very wide range of soil and climatic conditions. Onions are grown to perfection on the alluvial soils of the Nile River Valley in Egypt, under the sea breezes of the South Sea Islands, on the delta lands along the seacoast, on sandy uplands, in the arid regions under irrigation, and on reclaimed swamp lands. There is perhaps no extensive area in the United States or its possessions where the onion, in one or more of its forms, can not be successfully grown, at least for home and local use.

The onion is of Old World origin and has been used as a food plant from the earliest historic times. It was an important article of diet in Egypt at the time of the building of the pyramids, and Moses, in his account of the exodus of the Children of Israel from Egypt, mentions it as one of the articles of food for which the Israëlites longed during their sojourn in the wilderness.

Onions were brought to North America by the early discoverers and became one of the common crops of colonial gardens. Commercial onion culture in its present form has developed mainly during the last 40 or 50 years. Formerly the production of onions for sale was confined principally to the New England States, but the industry soon spread to other sections, and when the vast muck areas of the Great Lakes and other regions were drained and brought under cultivation the onion soon became one of the most important crops on these soils.

At present the principal commercial onion-growing centers are located in New England, especially in the Connecticut River Valley, in northern New Jersey, southeastern New York, the entire Great Lakes region, and as far west as Minnesota. The production of Creole onions centers around New Orleans, La., and the greater part of the Bermuda-onion crop is grown in southwestern Texas and in California. Within the last few years the production of the mild Valencia onion has developed in several of the Western States, including New Mexico, California, Arizona, Utah, Nevada, Washington, and Oregon. In addition there are many local areas in the United States where onions are being grown in considerable quantities for the market.

The production of several crops closely related to the onion, such as chives, shallot, leek, and garlic, has been developed around local centers, especially in connection with market gardening near the large cities. Garlic might be mentioned as an exception, because it is produced mainly in a few localities where soil and climate are especially suitable for its growth.

The present acreage and production of onions in the United States is about equal to market demands. During years of short crops and low yields there is a shortage of onions with consequent high prices, but during years of heavy crops the supply, as a rule, exceeds the demand, and frequently prices are too low for profitable returns to the grower.

CLIMATIC REQUIREMENTS

For best results a temperate climate without great extremes of heat and cold should be selected. Onion culture is rarely profitable in regions where the climate does not change or has no definite seasons of heat and cold or moisture and drought. The onion does best under rather cool conditions, with plenty of moisture during its early stages, but requires a reasonable degree of heat, together with dryness of both soil and atmosphere, for its proper ripening. Where the onion industry has become established in the extreme southern part of the United States, the growing season is during the late autumn and winter, the crop maturing during the spring and early summer. If the crop matures at a time when there is considerable rainfall, it will be impossible to cure the bulbs without artificial means and they will be lacking in keeping qualities.

Certain types and varieties of onions, including the top onions and the multipliers or potato onions, are extremely hardy and may remain in the open ground throughout the winters of our Northern States, especially if given slight protection. These types are, however, not adapted to growing for market, except as green onions, "peelers," or "bunchers," to be sold during the early springtime. In certain sections of the South Atlantic coast region large areas of the top and multiplier onions are grown for this purpose. There is also a marked difference in the temperature requirements of the standard commercial sorts, some being adapted to growing far northward, while others, like the Bermuda, Egyptian, and Spanish types, do best in restricted southern localities.

The period required for the production of a crop of onions will depend upon the season, the methods employed in growing, and the

variety. If grown from seed, a period of from 130 to 150 days will be required. If from sets, the crop often may be matured in 100 days. If grown in the extreme northern part of the United States, where the seasons are short, the crop will mature more rapidly than to the southward. In the case of the Bermuda onion, as grown in Texas, the growing season extends from October to the following March or April.

Onions require an abundance of moisture during the early stages of their growth, but should be ripened under comparatively dry conditions. In most sections the seed is sown at a time of the year when frequent spring rains occur. Their period of greatest growth is during the early part of the summer, and the crop is ripened late in the summer when drying conditions may be expected. In irrigated regions the application of water is almost entirely under the control of the grower. During the active period of growth the water is applied about once a week, the soil being thoroughly soaked and the surplus water drawn off.

The amount of rainfall or irrigation required for the production of a crop of onions will depend largely upon the character of the soil and its drainage. Many of the peat or muck soils in which the soil water remains near the surface will require very little rainfall; in fact, the best crops of onions are produced on these soils during seasons of comparatively light but evenly distributed rainfall. Sandy and loose soils generally will require a greater amount of water, especially during the early part of the season.

SOILS ADAPTED TO ONION CULTURE

The essential requirements of a soil upon which to grow onions profitably are a high state of fertility, good mechanical condition in order that the crop may be easily worked, sufficient drainage, and freedom from weeds. If a soil has the proper mechanical properties—that is, if it contains sufficient sand and humus to be easily worked, is retentive of moisture and fertilizers, and is capable of drainage—all other requirements can be met. At least three types of soil are being extensively planted to onions in this country, the one common essential being proper mechanical condition.

Clay and alluvial loam soils abound in the river valley and delta regions near the coast. These soils are generally very fertile, but may require the addition of humus or stable manure in order to lighten them. The greatest difficulty encountered in growing onions upon land of this character is the tendency of the soil to run together and bake after hard rains. This is especially injurious after the seed has been sown and before the small plants have attained sufficient size to permit of stirring the soil about them. Where these soils contain considerable sand they are ideal for onion culture. It is upon this class of soil that the greater part of the Bermuda, Spanish, and Egyptian onions are grown.

Sandy soils, especially where underlain by a well-drained clay subsoil, are often well adapted to onions. Soils of this character generally require heavy applications of fertilizers before they will produce a paying crop, but the quality of the product is excellent. Onions grown on sandy loams are generally solid, heavy, and of excellent keeping quality. Where sandy soils are lacking in humus

this may often be applied by means of crops of legumes grown upon the land and plowed under.

Throughout the north-central part of the United States there are vast tracts of peat or muck soils that are capable of producing onions. Before planting to onions, however, these soils must be cleared, drained, and brought to a suitable state of cultivation. In many cases this process will require two or three years' time, but sometimes the soil can be broken during the early winter, allowed to lie exposed to the action of frost, then worked down and planted to onions the following spring. Some of the largest onion farms are located on muck lands. The store of plant food in muck soil is usually large, but often it is not in available condition, and heavy applications of manure and commercial fertilizers, especially superphosphate and potash, are essential to profitable crops.

CULTURAL METHODS

The onion belongs to that class of crops which gives best results under very intensive culture, and the greatest yields are secured where a moderate acreage is planted and the work conducted in a most thorough manner. There is nothing technical about the growing of onions, but close attention and frequent cultivation are essential. Once the weeds get a start, the cost of production will be greatly increased, or the crop may be lost altogether.

PREPARATION OF NEW LAND

As a general rule new land is not adapted to onion growing until it has been worked one or two years with other crops. Onions should follow some row crop that has been kept free from weeds the previous season. Corn, beans, and potatoes are suitable crops with which to precede onions. Muck and sandy soils may in some cases be brought to a suitable condition for onions the first season, but the fitting will have to be very thoroughly performed. The land should be plowed in the autumn, then replowed in the spring, after which numerous harrowings and doubtless some hand work will be required to get the soil in suitable shape.

If necessary to manure the land heavily before planting to onions, it will be desirable to plant to some farm crop one season, then apply the manure during the autumn in order to give it time to become incorporated with the soil. Owing to the value of good onion land it would not be advisable to devote it to general farm crops for any extended period, although corn is frequently planted and oats or rye are sometimes used in the North. Cowpeas may be of great service in bringing new land into shape for planting to onions.

CROP ROTATION

Onions should not be planted on the same piece of land year after year, but some system of crop rotation should be maintained. Care should be taken, however, to use crops in the rotation that will not be exhaustive of the high fertility necessary in the onion land. During the years when the land is not devoted to onions it can be planted to some truck crop that will give a return that will justify the appli-

cation of large quantities of fertilizers, or, better, to a leguminous crop to be turned under as green manure. Continuous cropping with onions will cause the land to become infested with both disease and insect enemies that will sooner or later injure the crop to such an extent as to render it unprofitable.

PREPARATION OF THE SOIL

Assuming that the land intended for planting to onions is capable of being brought to a good mechanical condition, is fertile, well drained, and reasonably free from weed seeds, the first step in the production of the crop will be to plow moderately deep, then harrow, disk, roll, and drag until the soil is smooth and mellow to a depth of 5 to 7 inches. The method of preparing the soil will depend somewhat upon its character, the manner of planting to be followed, and the requirements for irrigation. There are few truck or other crops that require so careful fitting of the soil as do onions, and it is essential that the fertilizers be well mixed with the soil.

On soils that are naturally well drained and where surface water can not accumulate, the plowing may be done in large blocks, but where the opposite conditions are found or irrigation is practiced it may be necessary to plow the land in narrow beds. In the case of insufficient drainage it will be desirable to throw the soil into beds, leaving double furrows between the beds to carry off surplus water. Where the flooding system of irrigation is practiced the beds must be leveled and a system of ditches and ridges provided for distributing and controlling the water. Where it is merely desired to secure surface drainage the beds may be from 75 to 150 feet in width, but for irrigation purposes the beds are generally but 12 or 15 feet in width. If spring plowing is practiced the soil should be harrowed closely behind the plow in order to prevent drying out.

For cutting and pulverizing the soil there is perhaps no tool as serviceable as the disk harrow. There is a type of disk having four gangs, in two sets, one combination in front of the other and so arranged that the soil is first turned to the center and then turned outward again by means of the rear combination. This tool turns the soil twice and leaves it in a level condition. For smoothing and leveling the soil behind the plow a harrow of the type shown in Figure 1 is very desirable; this tool not only levels but turns and crushes the soil at the same time.

On land that has been plowed during the autumn and requires replowing in the spring, a device of the type shown in Figure 2 will answer and will do the work more rapidly than the plow. This tool is especially adapted to bedding up land that has been previously plowed.

For imparting the final smoothing touch to the soil before planting there is a device consisting of a large number of small disks set in a wooden frame (fig. 3) which does about the same work as a steel rake, but in a rapid manner. A drag or float made from several pieces of scantling nailed together may be used for this purpose, or if the soil is very loose a roller should be run over it. The final leveling should be performed with a tool that will fill and obliterate all tracks or other depressions in the soil, leaving a smooth, even seed bed for either seed sowing or transplanting.

FERTILIZERS

As the onion is an intensive crop and should yield great quantities of marketable bulbs for the area planted, the grower is justified in fertilizing heavily. It would be difficult indeed to make the soil too rich for onions, provided the manures are thoroughly incorporated with the soil. A heavy application of fresh raw manure just before planting would have an injurious effect, but where the manure is well rotted and uniformly applied there is nothing to be feared.

ANIMAL MANURES

There is perhaps no fertilizer so well adapted to the production of onions as plenty of disease-free, well-composted stable manure, and the quantity and frequency of application will depend upon the nature of the land under cultivation. The Bermuda-onion growers of southwestern Texas apply as high as 20 tons of sheep and goat manure to an acre every three years. In addition to the manure there is used 1,000 to 2,000 pounds of cottonseed meal or commercial fertilizer, and sometimes a top-dressing of nitrate of soda. This sheep and goat manure, from animals that are fed largely on cottonseed meal, is saved in the corrals in a climate where there is very little rain, and contains the essential fertilizing ingredients in very high percentages. The manure is first piled where a little water can be thrown over it and it is composted for several months before spreading on the land. The best results from this manure are not realized until the second or even the third year after its application.

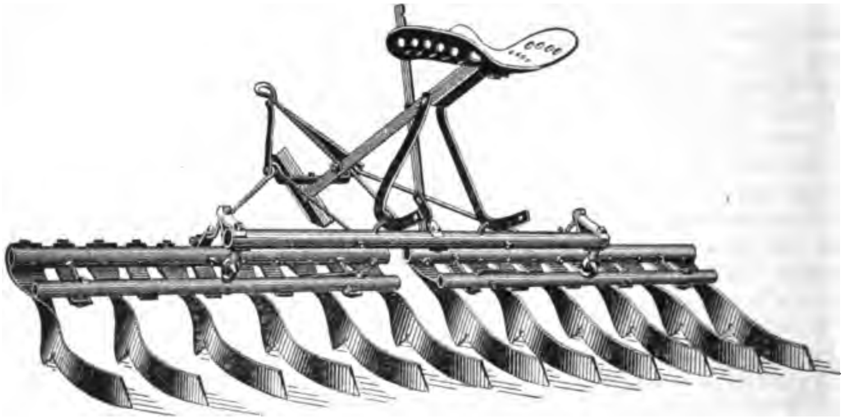

FIGURE 1.—Harrow for smoothing and leveling the soil behind the plow

All stable manure used on onion land should be well composted before use and then spread upon the land several months before planting to onions. In the Northern States the manure may be applied during the autumn and well disked into the soil. The land can then be allowed to lie in the rough state and exposed to the action of frost during the winter, or it can be smoothed and seeded to rye, in which case it will be necessary to replow early in spring. In the Bermuda district the manure should be applied during the

spring and the land kept frequently stirred during the summer, with occasional irrigations in order to incorporate the manure and destroy weeds; the planting is not done until the autumn. Another practice in the Bermuda district is to apply fresh manure broadcast at the rate of 10 to 12 tons to the acre during the spring, then plant to corn and cultivate through the early summer, and add a top-dressing of well-rotted manure after plowing the land for onions in the autumn. This top-dressing should be well worked into the soil by means of disk harrows. Large quantities of fresh manure applied on onion land just before planting will have a tendency to produce an overgrowth of tops at the expense of the bulbs. This is especially true on irrigated lands and soils that are naturally moist.

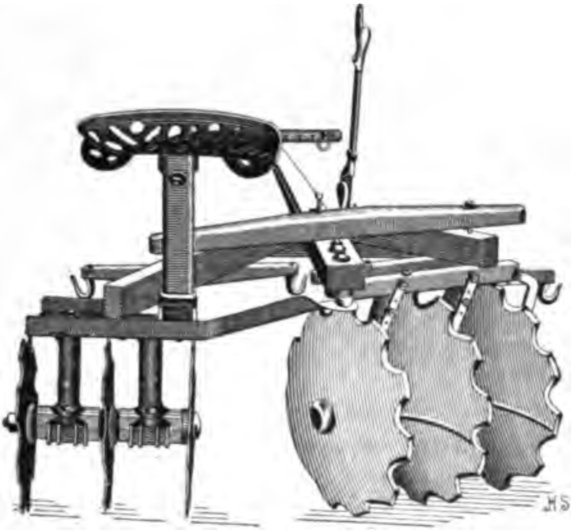

FIGURE 2.—Disk plow used for refitting land

COMMERCIAL FERTILIZERS

A fertilizer that is suited to the growing of potatoes will serve quite well for onions, but the potash should perhaps be supplied in the form of muriate rather than of sulphate. A fertilizer adapted to the growing of onions should contain 4 to 5 per cent of nitrogen, 8 to 10 per cent of phosphoric acid, and 8 to 10 per cent of potash.

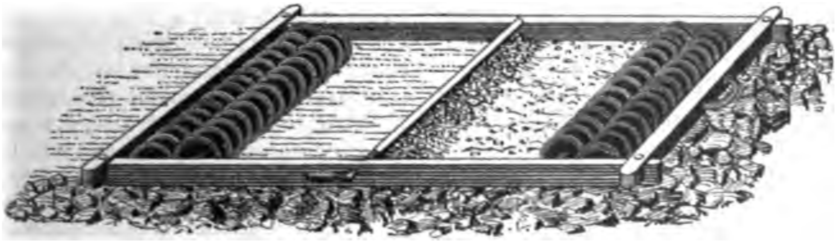

FIGURE 3.—Device used for smoothing soil before seeding

A fertilizer of this character will cost $40 to $45 a ton and can be profitably applied at the rate of 1,000 pounds to the acre on most soils. Where very intensive cultivation is practiced it may be profitable to apply as much as a ton to the acre in addition to stable manure.

Commercial fertilizers should be applied shortly before sowing the seed and should be uniformly distributed and thoroughly worked into the soil. There are fertilizer distributors that scatter the fertilizer broadcast, but where an amount not exceeding 1,000 pounds of fertilizer to the acre is being used the work of distribution may be performed by means of a common grain drill having a fertilizer attachment. On a small scale the work is generally performed by hand.

Many growers follow the practice of applying only a part of the fertilizer at planting time, reserving the balance to be put on as a top-dressing at some time during the period of cultivation. This plan is especially desirable where onions are grown during the winter, as the application of highly nitrogenous fertilizers in the autumn is liable to promote a soft growth that will be injured by cold. If the fertilizer is not put on until cold weather is over, the crop may be forced without danger of injury. For this purpose only those fertilizers of a very available form will answer. Nitrate of soda is frequently used as a top-dressing during the height of the growing period.

PLANTING

Most of the onions grown in the United States are started from seed. Propagation from seed is conducted by three more or less distinct methods: (1) By sowing the seed in the rows where the crop is to grow and mature; (2) by sowing the seed in specially prepared beds and transplanting the seedlings to the open ground; and (3) by first growing sets from seed and then, after keeping them through the winter, planting them in the field to produce the crop of mature bulbs. Of these three methods the one first mentioned of seeding in the rows where the crop is to mature is the one most used on a very large scale.

SEEDING IN ROWS

In the northern onion-growing districts the seed is sown as early in the spring as the soil can be brought to the proper condition. While it is desirable to plant quite early, it never pays to sow the seed before the land is in the best possible condition. When the soil has been brought to a smooth, even surface and is fine and mellow, the seed is sown by means of a common seed drill, of which there are several makes on the market. The hand drills which sow one row at a time are extensively employed, but many of the larger growers employ a gang of drills hitched together and plant from five to seven rows at once. In heavy or moist soils the depth to cover the seed should not be more than one-half to three-fourths inch, while on loose and sandy soils the seed may be covered about an inch.

Where hand cultivation is practiced throughout, the usual distance between rows is 12 to 16 inches. Where horse culture is employed the distance between rows varies between 24 and 36 inches. The quantity of seed required to plant an acre will depend both upon the distance between rows and the purpose for which the onions are being grown. For the growing of standard market onions in rows 14 inches apart, about 4½ pounds of first-class seed will be required. With the rows 3 feet apart, but 1¼ to 1½ pounds will be necessary. Where it is

desired to produce small onions for pickling purposes, the amount of seed may be as great as 25 pounds to an acre. Good seed is essential, and if there is any doubt regarding the vitality of the seed it should be tested before planting by counting and planting 400 or 500 seeds in a window box and then determining the germination by counting the seedlings after 10 days' or 2 weeks' time. First-class seed is seldom sold at a low price and good seed at $1.50 or even $2.50 a pound may be cheaper in the end than poor seed at 50 cents. Old and inferior seeds are not only low in percentage of germination, but lack the vitality necessary to produce strong, healthy plants. There are dealers who make a specialty of securing and furnishing extra-quality onion seed, and while their prices are often somewhat above the general market the seed furnished by them is preferable to ordinary seed.

Experienced growers are able by using extreme care in regulating the drills to distribute onion seed in rows where the crop is to mature so that little thinning will be necessary. Thinning is generally left until the time of the first hand weeding, when all thick bunches along the rows are thinned to a uniform stand of 8 or 10 plants to the foot. It is always well, however, to allow for considerable loss of plants, and unless the plants are so thick as to actually crowd, thinning will not be necessary.

TRANSPLANTING METHOD OF GROWING ONIONS

The transplanting process is merely a modification of the regular seeding method. The objects gained by transplanting are an earlier crop, a uniform stand, and bulbs of more regular size. Practically the entire crop of Bermuda-type onions grown in the United States is handled in this manner. Where a small area is to be grown, the transplanting process is the ideal method, but for large acreages where labor is difficult to obtain this would not be practical. After transplanting, the seedlings will require rain or watering, and for this reason the transplanting process is practically limited to areas where some form of irrigation is available.

In growing onions by the transplanting method the seed is sown in greenhouses, hotbeds, coldframes, or specially prepared beds at the rate of 3½ or 4 pounds for each acre to be planted. Onion seedlings are now being grown in great quantities by southern plant growers and are shipped to northern onion growers. When the seedlings are grown under cover, they are given the necessary attention regarding watering and ventilation and kept growing quite rapidly until near the time for setting them in the open ground. As planting time approaches, the seedlings are "hardened" or prepared for transplanting by increased ventilation and exposure and by withholding water. When ready to transplant, the seedlings should be somewhat smaller than a lead pencil and rather stocky. The plants are lifted from the seed bed and the roots and tops both trimmed somewhat, as shown in Figure 4. They are then packed neatly in shallow boxes for removal to the field where they are to be planted.

Various methods are employed for handling the plants in setting. As a rule, a line is used and the land marked to indicate the location of rows. Several methods are employed for marking the distance

between plants in the rows. A marking device much used by the Bermuda-onion growers in Texas consists of a sectional roller with the sections the same distance apart as the distance between the rows and each section provided with conical pins to form the holes in which the plants are set. The objection to the sectional roller marker is that it can not easily be drawn in a straight line and straight rows are essential to good cultivation.

After marking the land, the plants are dropped ahead of the planters, or they may be kept in the trays and simply removed as planted. The transplanting process consists mainly in pushing the root end of the seedling into the soil with one finger and then firming the soil about the plant. This work is very laborious and can only be performed economically by very cheap labor. A small plow, such as is generally included with the attachments of the wheel hoe (fig. 5), is often employed for opening a furrow in which to set the small onion plants. As the plants are set the soil is either drawn about them by hand, or the plow may again be used for this purpose. In the Bermuda-onion district the work of transplanting is as a rule done by contract. In transplanting, all inferior plants should be rejected, thus insuring a more nearly perfect stand and development.

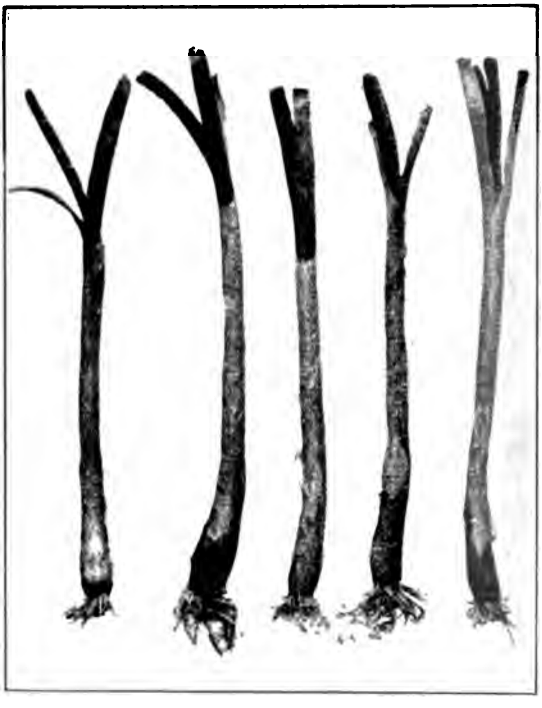

FIGURE 4.—Seedling onion plants trimmed ready for transplanting

PROPAGATION BY SETS

The use of sets is still another modification of the regular seedling method, in which the seed is planted one year to form the sets from which to grow a crop of mature onions the following year. Like the transplanting process the use of sets is limited in its application. Onions grown from sets will ripen earlier than those from seed sown in the field, but the use of sets for commercial onion growing is not so practical as transplanting seedlings, because of the high cost of sets. In planting onion sets a furrow about 2 inches deep is opened, the sets being dropped about 3 inches apart and firmly covered. The quantity of sets required to plant an acre will depend upon their individual size and planting distances, but it is generally between 15 and 22 bushels.

CULTIVATION

The cultural requirements of the onion are frequent shallow stirring of the soil and freedom from weeds. The feeding roots of the onion run close to the surface of the soil and should not be disturbed by deep cultivation. Sometimes a heavy rain immediately after seeding will so pack the surface that the seedlings can not break through. Under such circumstances it will be necessary to slightly break the surface by means of a steel rake or a rakelike attachment on a cultivator. As soon as the plants are up and the rows can be followed the cultivator should be started to loosen the soil, which is always more or less compacted during seeding.

HAND CULTIVATION

Where the rows are 14 inches or less apart, the work of caring for the crop must all be done by hand. For this purpose the wheel-hoe tools of various types are essential. These implements are provided with several kinds of hoes, cutters, and sweeps designed to work the soil away from the plants, to shave the surface and destroy weeds, and to stir the soil and work it back around the plants. Onions grown on muck and alluvial soils will require from 8 to 14 workings with the wheel-hoe implements; on sandy soils it will not be necessary to cultivate so frequently.

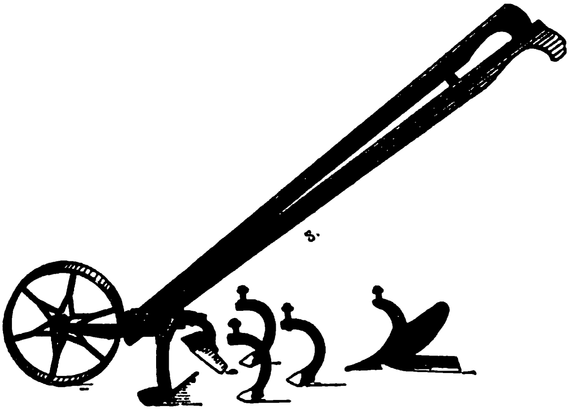

FIGURE 5.—Wheel hoe adapted to working onions

Several types of wheel hoe are in use, but those having a single wheel and passing between the rows are most desirable. Those of the type shown in Figure 5 are good. Many growers have designed special implements to suit the requirements of their soils; two of these are shown in Figure 6, the one designed to cut the soil away from the row and the other to stir and work the soil back to the row. Some of the growers in the onion fields near Chicago have adopted a hoe stock consisting of a pair of light plow handles, an iron stock, and the front wheel of a bicycle. To the stock of this device may be attached almost any form of sweep or cutter, and the implement is exceptionally easy to propel. The wide distance between the handles places the implement well under the control of the operator. Figure 7 gives an idea of the general appearance of this implement.

HORSE CULTIVATION

In sections where onions are grown on a soil that is not well adapted to hand culture the rows are placed 30 to 36 inches apart

and the cultivation is performed by means of horse-drawn tools. This is particularly true where onions are grown on the black waxy soils of Texas and other soils of the prairie type. As with hand culture, frequent shallow stirring of the soil is essential, the work generally being performed with one of the harrow-tooth cultivators. Those of the type shown in Figure 8 are well adapted to this work. An implement known as a weeder can be used for breaking the surface before the seedlings appear; also for general cultivation by removing a tooth at the point where the rows are located.

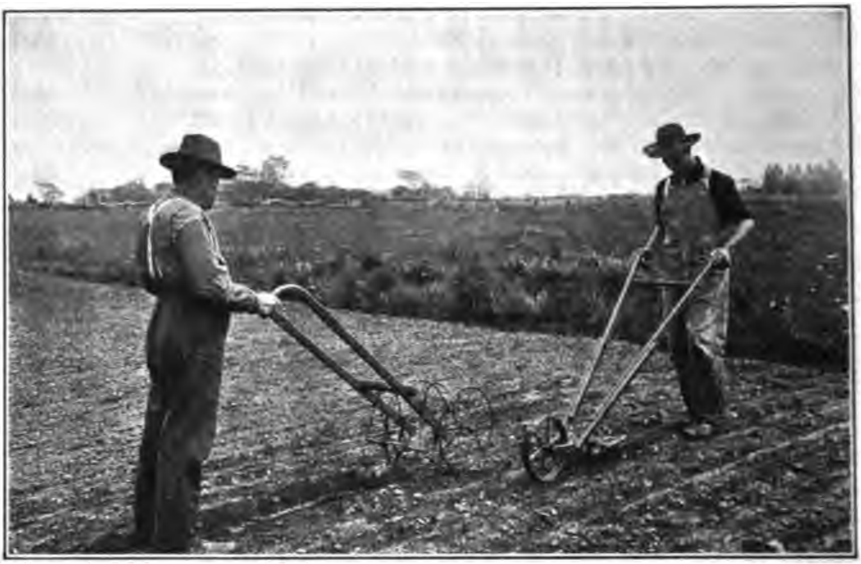

FIGURE 6.—Special wheel hoes for cultivating onions

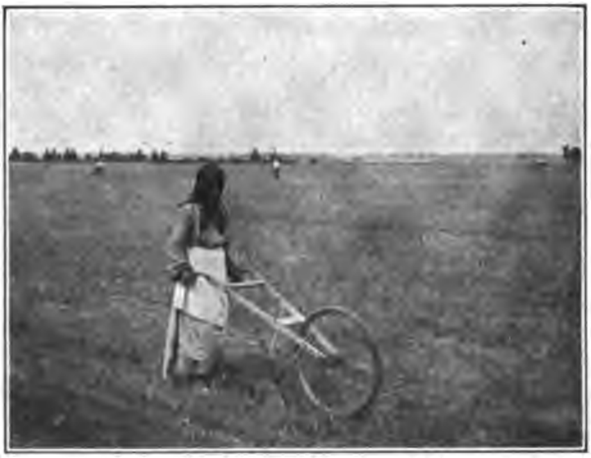

FIGURE 7.—High wheel type of hoe. (Patented)

HAND WEEDING

It is well-nigh impossible to produce a crop of onions without some hand weeding. During favorable seasons the strictly handwork may be reduced to but one or two weedings, but a greater number will be necessary during rainy seasons. Each hand weeding will cost from $5 to $12 an acre, according

to wages paid and the number of weeds present. The work of hand weeding may be facilitated by the use of some of the small hand tools designed for the purpose. Among these tools might be mentioned the onion hoe (fig. 9), the hand weeder (fig. 10), and the thinning or weeding hook (fig. 11). Girls and boys are expert at hand weeding, the practice being to work them in gangs of 10 to 20 with an overseer behind them to see that the work is properly done. In some localities the wages paid for this class of work are $1.50 to $2.50 a day.

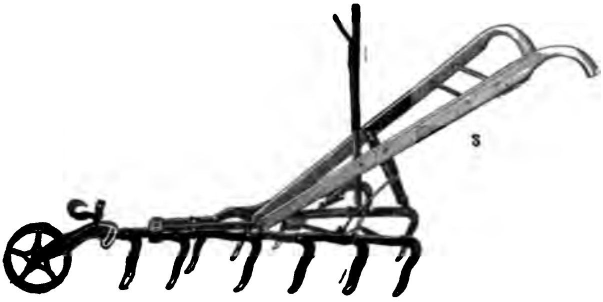

FIGURE 8.—Small-tooth horse cultivator

IRRIGATION

Outside of the areas where irrigation methods are depended upon for the production of general crops it is not customary to use artificial watering in the growing of onions. In a few cases the land has been equipped with overhead sprinkling systems which are employed to moisten the soil after the seed is planted and also during extremely dry weather. On peat and muck soils the young seedlings are frequently lost by the dry muck blowing with the high winds of early spring. In this way a part of the field may have the soil blown off to such an extent that the plants will be left without soil about them, while other portions of the field will be covered by 1 or 2 inches of loose muck. The use of a small quantity of water sprayed over the field will sometimes prevent this shifting of the soil during a windstorm but will not prevent the accumulation of muck blown on to the plants from adjacent nonirrigated areas. Sandy soils are also subject to the action of winds to a greater or less extent, and losses may be prevented by the timely application of water over the surface. In a few instances subirrigation is employed in the growing of onions.

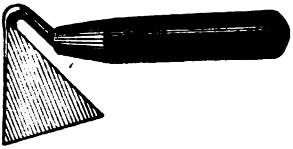

FIGURE 9.—Onion hoe

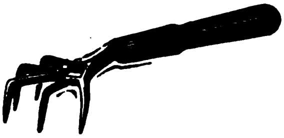

FIGURE 10.—Hand weeder

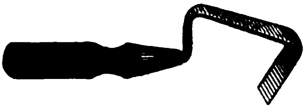

FIGURE 11.—Thinning or weeding hook

Throughout the Bermuda district of the Southwestern States surface irrigation is almost universally employed. The Bermuda onions are planted mostly in comparatively level beds with dividing ridges and are flooded once each week or 10 days during the growing period. About a week before the plants are set the soil is flooded

and then worked over with disk and smoothing harrows just ahead of the planters. Within a day or two after planting the land is again flooded and the surface water drawn off; this process is repeated, with alternate cultivations, as often as required. Toward the end of the growing season the water is withheld to allow the bulbs to ripen. As a rule about 10 waterings in all are required, at a cost of about $2.50 an acre for each watering, or $25 per acre altogether. Figures 12 and 13 give a good idea of the methods of applying the water in the Bermuda-onion growing district.

In the principal Bermuda-onion growing districts the water for irrigation purposes is obtained only after the expenditure of thousands of dollars for pipe lines and pumping machinery. The cost of watering as given above does not include any share of the original cost for installation or water charges, but covers only the labor.

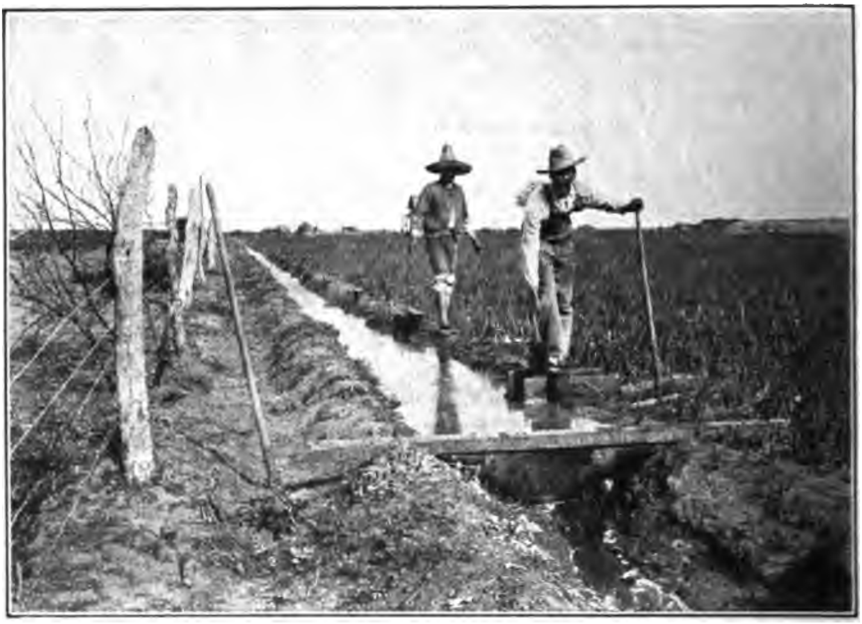

FIGURE 12.—Irrigation ditches in Bermuda-onion field in Texas

HARVESTING AND CURING

In the northern onion districts the crop ripens and is harvested during the latter part of the summer and early autumn. As a rule the work of harvesting onions begins late in July and is practically completed and the crop housed before October. In the Southern States, where the crop is grown during the winter, the harvesting and marketing period is during the spring and is practically ended before the northern product comes upon the market.

In the North the bulbs are allowed to become as ripe as possible before removing them from the soil. Growers prefer that the tops

ripen down and shrivel and that the outer skin of the bulbs be dry before they are pulled. Figure 14 shows a field of onions in prime condition for gathering. To the southward, where the onions are not cured so thoroughly, they are often pulled about the time that the tops begin to break and fall. The ripening process often may be hastened by rolling a very light roller or a barrel over the tops to break them down. This process is frequently spoken of as "barreling."

Where the bulbs are practically upon the surface they may be pulled by hand and thrown in windrows consisting of 8 or 10 onion rows. If the onion bulbs are considerably covered with soil it will be necessary to employ a 1-horse plow or a cultivator with a sweep attached for lifting them. In any case it will be necessary to gather them from the soil by hand. After lying in the windrows for several days and being stirred occasionally with wooden rakes, the tops are removed either by twisting or cutting with ordinary sheep shears. In cases where very bright color is important, as with fancy White Globe onions, and this would be injured by exposure to the sun and rain, the bulbs are cured in long, narrow, low ricks formed by placing several rows of onions laid with the bulbs to the center and the tops to the outside to protect the bulbs. As the tops are removed the bulbs are generally placed in crates for drying. Onion-topping machines frequently are employed, the bulbs being hauled from the field to a central location and run through the topper. These machines remove the tops, grade the bulbs, and deliver them into the crates or bags. If crates are not employed for curing, the bulbs are allowed to lie in the windrows for some time, and are then either

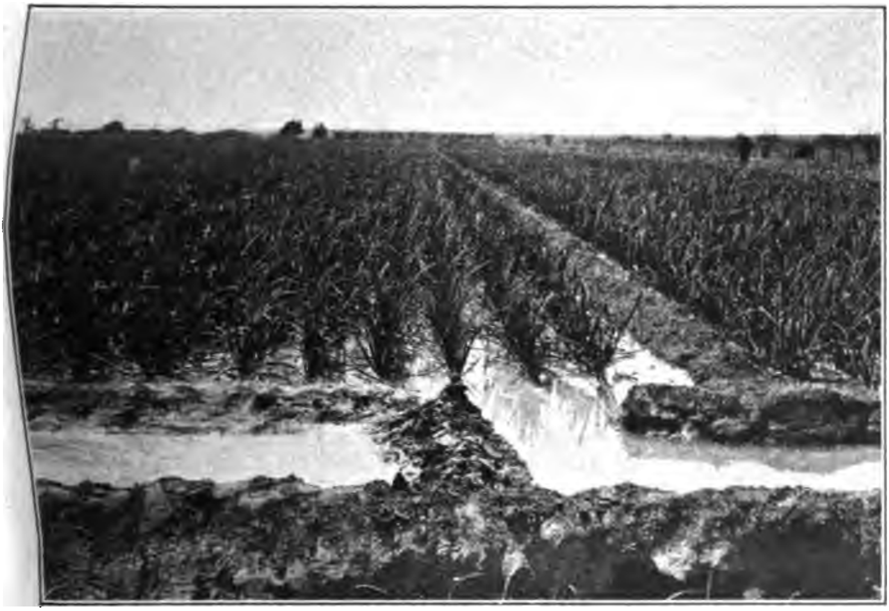

FIGURE 13.—Irrigation of Bermuda onions in Texas

put into sacks or hauled to slat cribs, where the curing process is completed. Too long exposure to hot sunshine will injure the bulbs. Figure 15 shows a field of onions drying in windrows, with crates ready for their removal from the field.

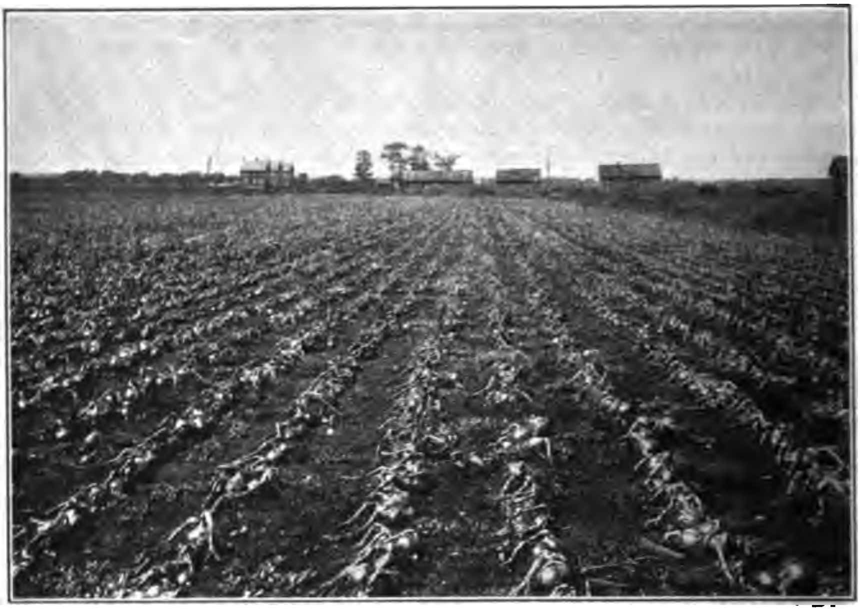

FIGURE 14.—Field of onions in condition for gathering

After gathering into crates, the crates are either stacked in the field, hauled to a central stacking yard where they are covered with boards or canvas, or hauled to open sheds and there piled one upon the other with numerous air spaces until the onions are thoroughly cured.

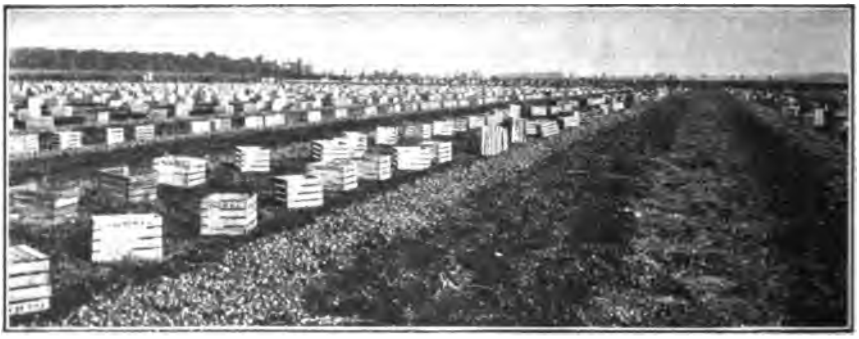

FIGURE 15.—Onions drying in windrows, showing crates used for curing and storing

Where the bulbs are extremely dry at the time of their removal from the soil, they may be allowed to lie in the windrows for a few days only, and then sorted and cleaned in the field ready for packing and marketing. Where onions are put into sacks and afterwards

allowed to remain in the field, the sacks should be supported on poles laid on the ground, as shown in Figure 16.

In the Bermuda-onion districts, where only a short curing process is given to the crop, it is the practice to pack and load into the cars as soon as possible after pulling and topping. When the shipping is at its height, it is not uncommon for onions that are pulled from the soil in the morning to be in the cars and on their way to market by evening; however, a portion of the crop is given a more thorough curing process, and the entire crop would be benefited by at least two days of curing before shipment.

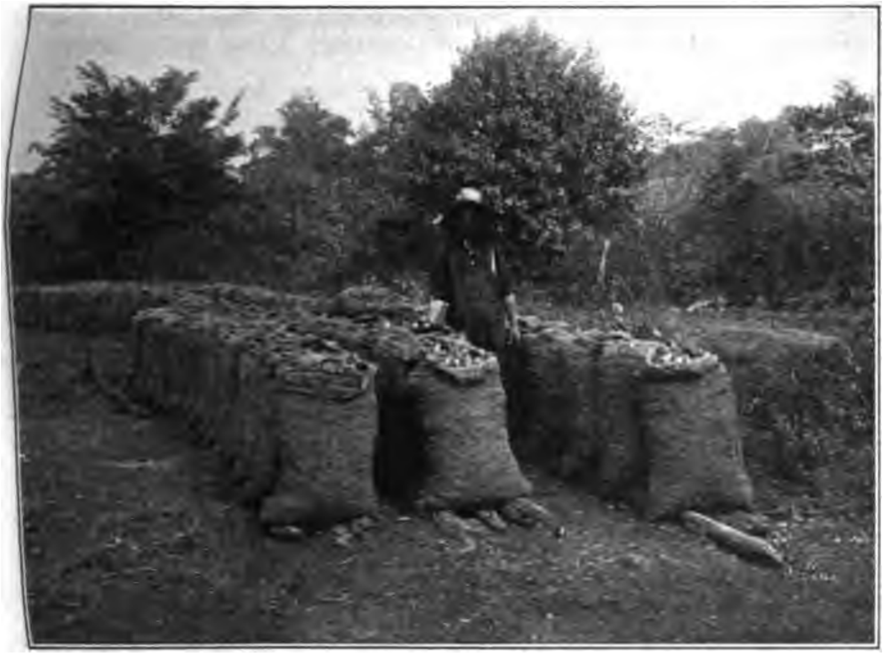

FIGURE 16.—Method of curing onions in sacks standing in the field

STORAGE

In order that onions should keep well when stored they must be well ripened and thoroughly cured. "Thick necks" or those that are immature, or soft, should never be placed in storage but should be sold as soon as gathered for whatever price they will bring. Good storage onions will rattle almost like blocks of wood when poured from one crate to another. In order that the bulbs may remain bright and of attractive appearance they should not be allowed to lie exposed to the weather, but should be hauled and stored in open sheds just as soon as they may safely be placed in 1-bushel crates.

After the bulbs have remained in drying sheds or cribs for four or five weeks they will be ready for screening and removal to the storehouse. In handling onions it is the rule to pass them over a screen each time they are moved, as in this way the loose skins are removed and any soft or decaying bulbs may be sorted out. When bags are

used for drying in the field, the onions are screened in the manner shown in Figure 17, and the bags refilled for hauling to the storage house.

The essentials for the successful storage of onions are suitable containers, plenty of ventilation, a comparatively low temperature, dryness, and safety from actual freezing. Any building wherein the above conditions may be secured will answer, but houses of the type shown in Figure 18, which are built especially for the purpose, are most satisfactory.

The construction of the storage house should be double throughout, with plenty of felt or paper lining. Both top and bottom ventilation should be provided, and the ventilator openings should have doors that may be closed to control the temperature. The floors are constructed of narrow planks with half-inch spaces between the planks for the passage of air. Bottom ventilation is frequently secured by means of drainpipes built into the foundation at the surface of the ground. These pipes are carried some distance toward the center of the house and discharge the cool air at a point where it is most needed.

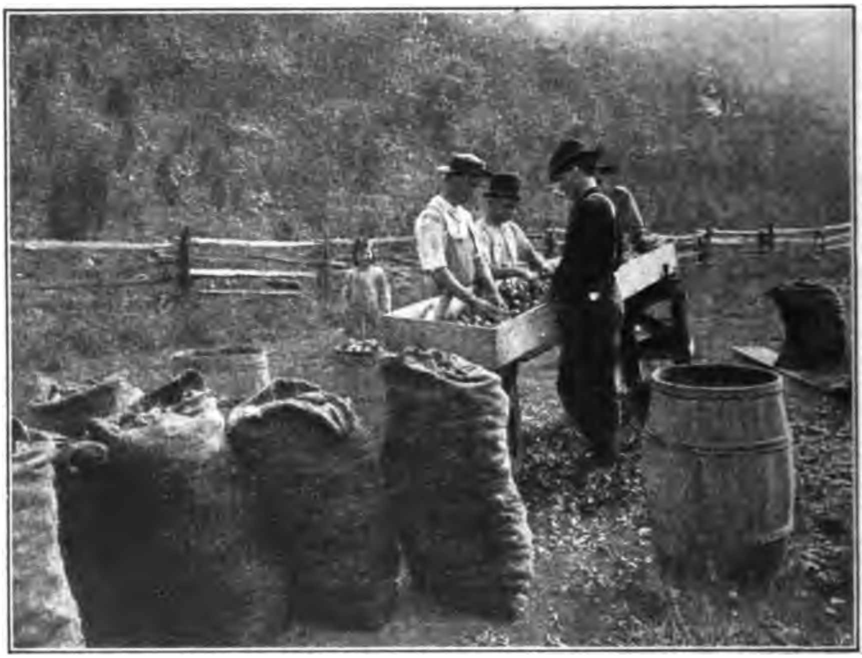

FIGURE 17.—Grading onions in the field by means of a screen

The temperature of the storage house should be carried as low as possible without actual freezing. During extremely cold weather the ventilator openings and doors should be kept closed to keep out cold air, and after the onions have become thoroughly chilled the house should be kept closed in order to hold the temperature down and prevent the entrance of moisture during warm or rainy periods.

Damp, foggy weather is injurious to onions, especially if it follows a period of cold, and will cause the bulbs to become covered with moisture if the outside air is admitted. A little artificial heat from a stove or radiator may be required during excessively cold weather, but so long as the temperature in the house does not fall below 32° F. there will be no danger of injury. A temperature of 36° to 38° will give good results.

The best method of storing onions is in standard-size slat crates 20 inches long, 16 inches wide, and 14 inches deep, outside measurements. The material for the sides and bottom is about three-eighths inch thick and 2½ inches wide, four pieces being used to form a side. The corners are reinforced on the inside by means of 3-cornered pieces of oak, to which the slats are nailed. These dimensions provide crates that are interchangeable, the width of five being equal to the length of four. The crates will also nest together when empty, with one inside of two turned together. The full crates are stacked in the storehouse with 1 by 3 inch strips between them to allow for the circulation of air, as shown in Figure 19.

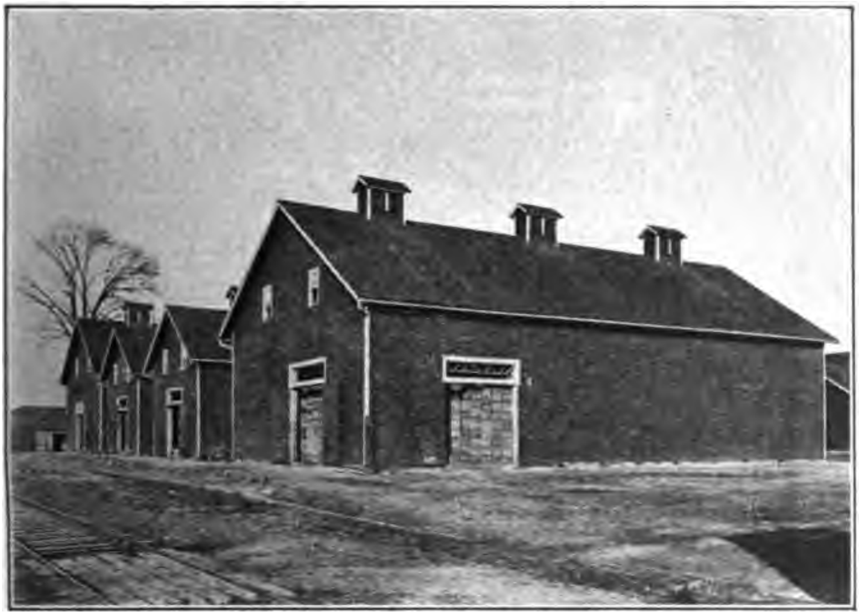

FIGURE 18.—Onion storehouses

Onions are sometimes stored in slat bins holding 100 to 300 bushels each. Bags are also used to some extent, but neither bags nor bins are as satisfactory as the crates, on account of the difficulty in providing the necessary ventilation and change of air through the onions. Bulbs stored in bags or bins must be more thoroughly cured than those stored in crates. There are single large storehouses in use that will accommodate 50,000 to 60,000 bushels of onions when stored in crates.

MARKETING[1]

Large quantities of onions are sold and shipped direct from the fields where they are grown. A part of the crop is held in temporary storage until late autumn or early winter. During recent years the winter storage of onions has become of great importance, and the finest stock is held for late-winter deliveries. The Bermuda crop from the southwestern part of the country comes on the market during April and May, so that most of the storage onions are disposed of before that time.

In marketing onions the first essential is to properly grade and clean the bulbs, in order that they may present an attractive appearance when offered for sale. Ordinarily the bulbs are separated into three grades—primes, seconds, and picklers. The primes include all of those 1¼ inches in diameter and larger, and the seconds consist of those from three-quarters of an inch to 1¼ inches in diameter, while all those that will pass through a ¾-inch screen are sold for pickling purposes. The grading is generally done in the field during the cleaning process, but as onions shrink considerably while in storage it is necessary to regrade before placing upon the market. The type of screen used for grading onions is shown in Figure 20. For cleaning the pickling onions an ordinary fanning mill is employed, special screens being provided for the purpose.

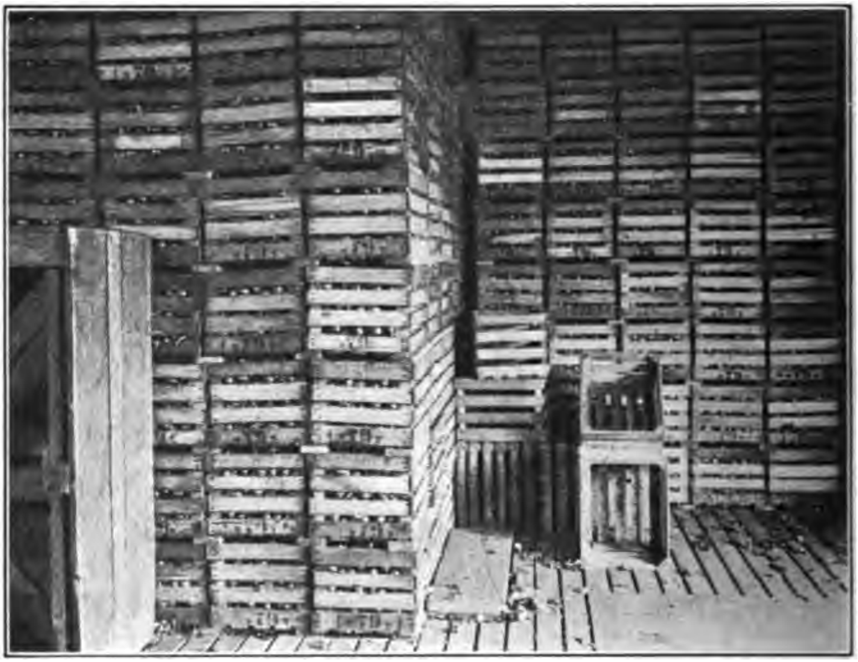

FIGURE 19.—Inside of storage house, showing method of stacking crates

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[1] For detailed information on the marketing of onions, see the following: United States Department of Agriculture Bulletins No. 1283, The Marketing and Distribution of American-Grown Bermuda Onions, and No. 1325, Marketing Onions.

Onions are placed upon the market in 1-bushel crates, bags, barrels, 1-bushel hampers and baskets, and in bulk. The folding crate, shown in the foreground of Figure 20, is undoubtedly the most attractive package in use for marketing onions. The bags employed are of special open-mesh weave and hold 100 pounds. Onions are sometimes shipped loosely in cars and shoveled into barrels or bags at their destination.

The legal weight of dry onions is generally considered 56 pounds to the standard bushel, although this varies somewhat in different States.

COMMERCIAL VARIETIES

For trade purposes onions are divided into two classes as " strong " onions and " mild " onions. The strong onions include the greater part of those grown in the northeastern United States and constitute the main storage and winter-marketing crop. This group includes such varieties as Yellow Danvers, Yellow Globe Danvers, Southport Yellow Globe, Ohio Globe, Japanese or Ebenezer, Australian Brown, and Red Weathersfield. The mild-flavored group includes the Red Bermuda, White Bermuda, Crystal Wax, Valencia, and others.

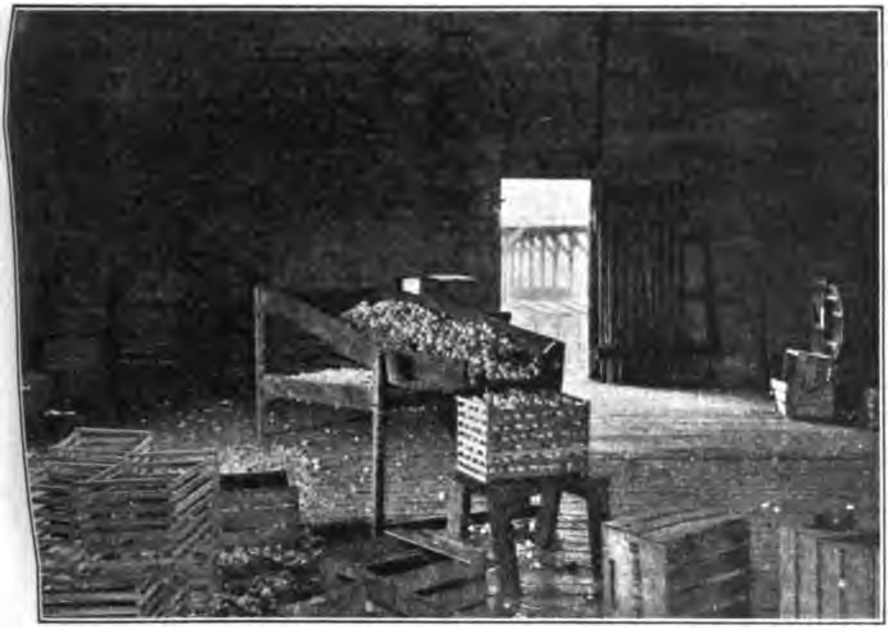

FIGURE 20.—Screen used for grading and cleaning onions, showing folding crates sometimes used for marketing

In the selection of varieties for any particular locality the soil and climatic conditions and market requirements should both be considered. Those adapted to the muck soils are the yellow and red sorts. For alluvial and prairie soils the red and brown varieties are to be preferred, while all kinds do well on the sandy loams and light soils. A cleaner, better grade of white onions can generally be pro-

duced on light or sandy soils than on muck or clay loams. Those of the Bermuda, Spanish, and Egyptian types flourish on the deep, rich alluvial soils of the river bottoms and delta regions.

Certain of our markets show a decided preference for onions belonging to a particular type. The red and brown varieties find ready sale on the markets of the Middle West, while onions of the yellow and white varieties are preferred in the eastern cities. Onions will withstand long-distance shipment, those of the mild type being generally more subject to injury than the strong sorts. Some of the white varieties also have a thin skin and are easily injured. It should be the aim of every grower to employ varieties that will withstand handling and at the same time find ready sale on the market.

The top or tree onion, which reproduces by means of small bulblets formed on the top of the seed stalk, is extensively used in the production of early-spring bunching onions.

The multiplier or potato onion produces by a division of the bulbs. In growing this variety it is necessary to plant large bulbs to produce sets for the next year's planting and small bulbs or sets for the crop of large onions. The bulbs of this variety may remain in the soil year after year and are desirable for use early in spring.

Garlic is closely allied to the onion, but will remain in the ground from one year to another in a mild climate if undisturbed. Garlic is planted by setting the small bulbs, or cloves, in either the autumn or early spring. The culture is practically the same as for the onion.

The leek also belongs to the same class as does the onion, but requires somewhat different treatment. The seed is usually sown in beds and the plants transplanted about 4 inches apart in the row. The plants of the leek are given about the same cultivation as onions, except that after they have attained almost full size the soil is drawn around them to a height of 6 or 8 inches to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored in cellars for winter use.

PRODUCTION OF BERMUDA ONIONS

Bermuda onions are now an important commercial crop in Texas and California, with small plantings in a number of the Southern States. The Bermuda onion fields of Texas are located around Laredo and other points in or near the Rio Grande Valley.

SOILS AND CLIMATE ADAPTED TO THE BERMUDA ONION

Soils of a silty or alluvial nature are suited to the production of Bermuda onions, and those containing considerable sand are most desirable. As already noted in referring to fertilizers for onions, the Bermuda requires a very rich soil for the best results, and this can only be obtained by first selecting a good soil and then manuring heavily. The Bermuda onion as grown in this country is a winter crop; therefore, mild climatic conditions are required. While the plants would withstand considerable freezing, their growth is seriously checked by cold weather, and the crop will not mature in time for the early market if grown to the northward.

CULTURAL METHODS

The cultural methods employed in the growing of Bermuda onions are essentially the same as those for ordinary onions. As the greater portion of the crop is grown in a region which has no regular rainfall, irrigation methods are employed almost universally. The greater part of the crop is grown by the transplanting process and a great amount of hand labor is required. The seeds are sown in specially prepared outdoor beds from the middle of September to the middle of October, and the seedlings are transplanted to the field November 20 to January 10, or even later. From 3½ to 4½ pounds of seed are required for each acre to be planted; this will allow for discarding all the weaker plants. The plants are allowed to remain in the seed bed until they are from three-sixteenths to one-fourth inch in diameter before they are transplanted. As the seedlings are lifted the greater portion of both the small roots and the tops is trimmed off in order that they may be transplanted more readily. (Fig. 4.)

HARVESTING AND MARKETING

Bermuda onions are harvested as early as possible, generally before the tops have become fully ripened. For removing the bulbs from the ground a 1-horse plow, a potato digger, or a cultivator with a cutter wing attached is employed. The bulbs are then separated from the soil by hand, the tops cut off with shears, and the onions thrown in windrows or piles to dry in practically the same manner as for the regular-crop onions in the North. After the bulbs have become thoroughly dry on the surface they are either placed directly in the crates for shipment or are carried to a packing shed to be graded and packed for market.

During the early days of the Bermuda-onion industry the crop was shipped largely in bags, but it was soon found that the bulbs were too perishable for this method of handling. At present the greater portion of the crop is sent to market in folding slat crates that are about 20 inches long, 12 inches wide, and 12 inches high.

These crates hold approximately 50 pounds of onions and weigh 56 or 57 pounds when filled. The cost of these crates is about $20 a hundred, but they add enough to the attractiveness and carrying qualities of the onions to make their use profitable.

YIELD OF BERMUDA ONIONS AND PRICES OBTAINED

Phenomenal yields of 34,000 and 35,000 pounds of Bermuda onions are frequently made on an acre of land, but this is far above the general average, which is in the neighborhood of 10,000 or 12,000 pounds to the acre. Many fields, especially when planted for the first time, do not yield as much as 10,000 pounds to the acre. On land that has been heavily manured and planted to onions for several years the yield averages about 16,000 pounds.

The best Bermuda-onion farms are valued at $300 to $500 an acre. In order to prove profitable, the growing of Bermuda onions should be conducted on a comparatively large scale. The necessary land and irrigation facilities will require the initial outlay of from $10,000 to $30,000, and the running expenses are quite heavy. Labor can be

secured at a low price, but is correspondingly inefficient and often not to be had in sufficient quantities. Furthermore, the markets are now pretty well supplied with Bermuda onions, and persons who desire to engage in their production are advised to investigate every phase of the industry before embarking too heavily in it. The expansion of the Bermuda-onion industry is limited by the facts that a large supply of bulbs can be grown on a comparatively small area, that the distance to market is great, that the product is perishable, and that the markets will consume only a limited quantity at the prices at which the crop can be sold with profit.

GREEN ONIONS FOR BUNCHING

Another phase of onion culture that is of considerable importance in certain localities is the production of young bunching onions for the early spring trade. In several sections along the South Atlantic coast the growing of this class of onions is quite an enterprise. Many persons who are engaged in other lines of work follow the practice of growing a small area of bunching onions as a side issue.

The varieties known as multipliers and top onions are generally employed for this purpose; however, bunching onions are sometimes grown from ordinary sets, from inferior and damaged large onions, and from seed.

CULTURAL METHODS

For growing bunching onions the bulbs or sets are planted during the autumn either in beds or in rows 12 or 14 inches apart with the bulbs quite close in the rows. The bulbs will start growing within a short time and make more or less growth during the winter. As soon as the weather becomes warm during the first months of spring the onions make a rapid growth and are ready for marketing about the time peach trees begin to bloom.

The land upon which these onions are grown should be rich and mellow, but very little actual cultivation will be required. Where the winters are severe it may be necessary to provide slight protection, either a little straw, loose manure, leaves, pine straw, or corn fodder that has been run through a shredder. If the onion beds are protected on the windward sides by means of a windbreak consisting of a grove of pine trees, a fence of boards, pine boughs, or corn fodder, the crop will be ready for marketing a little earlier than if left exposed. Multiplier onions not gathered for marketing are allowed to remain to form the bulbs for planting the following season.

MARKETING

In marketing this class of onions the young scallions are pulled, the roots trimmed, and the outside peeled off, leaving the stem white and clean. They are then tied in small bunches by means of soft white string, the tops trimmed slightly, and the bunches packed in crates or baskets for shipment or for sale on the local market. This phase of the onion industry is limited to small plantings and is well suited to the general market garden.

During the spring and early summer large quantities of ordinary young onions are pulled when the bulb is about the size of a 50-cent piece, the roots and tops are trimmed, and they are then bunched and sold for stewing purposes. So far as known, this class of onions is not shipped to any great extent, but is sold mainly on local markets.

DISEASES OF THE ONION

The onion crop of the United States is by no means free from disease. For information regarding such diseases and measures of control, the reader is referred to Farmers' Bulletin 1060, Onion Diseases and Their Control, which may be obtained on application to the United States Department of Agriculture, Washington, D. C.

ONION INSECTS[3]

In the United States the onion crop has only two serious insect pests. Of these, the onion thrips (*Thrips tabaci* Lind), because of its distribution over the entire country, is probably the most injurious. It is nearly always present on onions, and under favorable conditions it may increase to such an extent as to become very destructive. The onion thrips is a very small louselike insect, pale brown in color, and usually is first noticed because of the minute whitish spots which it leaves on the tips of the foliage after rasping away part of the leaf surface in feeding. The eggs are laid just beneath the surface of the leaf, and the insects, in both the mature and immature forms, feed on the surface from the sheath to the tip. In serious infestations the tops of the onions become grayish white, afterwards turning brown and dying. At such times the leaves, if examined, may be seen to be covered with thrips.

The onion thrips is particularly injurious in the South, and in the Texas Bermuda-onion district it is a constant menace to the crop. It is particularly likely to injure plantings which follow or are adjacent to such early crops as cabbage, from which the thrips migrate in great numbers at harvest time. A vigorous, strongly growing onion crop may grow away from thrips injury, but if for any reason growth becomes badly checked, damage is almost sure to result.

Thrips may be fairly well controlled by spraying with nicotine at the rate of three-fourths of a pint of a 40 per cent solution to 50 gallons of water in which 4 pounds of soap has been dissolved. Use a high-pressure sprayer and hold the nozzle close to the plants, as thrips often feed and remain protected in the leaf sheaths and creases. Clean up weed patches near the onion fields and rake together and burn the onion tops as soon as the crop is harvested. The grower should examine his onion plantings from time to time in order to detect the early stages of the infestation. It is easier to keep an infestation down by early treatments than to control a heavy infestation.

In the northern part of the United States the onion maggot (*Hylemyia antiqua* Meig.) often becomes very destructive, especially to small seedling onions. This pest is a white, footless maggot, the larva or young of a fly much resembling the common house fly, and is about three-eighths of an inch in length when full grown. The eggs are laid by the fly early in the spring, and are placed, in the case of seedling onions, on the ground near the plant, or in the sheaths of the leaves near the ground. On hatching, the young maggot burrows into the plant and bores through the stem and bulb, easily killing small seedlings. After killing one plant it proceeds to the next, thus causing many skips in the row. When larger plants are attacked, several larvæ may be found in the bulb.

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[3] Prepared by C. H. Popenoe, Division of Truck Crop Insects, Bureau of Entomology.

A remedy that has been used successfully in some sections consists of treating the soil about the plants with a Bordeaux-oil emulsion. The emulsion is best applied to the onion rows by means of a sprayer, the material being directed to the base of the plants. Enough of the material should be applied to moisten the soil at the base of the plants. The Bordeaux-oil emulsion may be prepared by adding 1½ gallons of oil emulsion, suitable for use against orchard scale insects, to 48½ gallons of 4–4–50 Bordeaux mixture. Apply five times at weekly intervals, beginning when the young plants are about an inch high. An effective treatment requires about 115 gallons of the spray per acre.

Cutworms are sometimes troublesome, but are easily controlled by the bran mash and arsenic bait, scattered thinly wherever the young seedlings have been found to be cut off.[3]

PRESENT STATUS OF THE ONION INDUSTRY

Because of variations in the cost of labor, tools, fertilizers, seed, and other materials and the many factors involved in the production of an onion crop it is impossible to give definite cost and profit figures. The average yield of onions is around 290 bushels to the acre, but yields of 400 to 600 bushels are not uncommon. The price of onions is extremely variable one year with another, but on the whole the crop has proved profitable to the growers when taken on an average for a period of years.

In some sections onions are grown in rows 3 feet apart and given horse cultivation, thus reducing the yield to about 150 bushels on an acre and cutting down production costs in proportion. This method of growing onions is especially adapted for use on low-priced land and where hand labor is scarce.

Both the supply and demand for onions are increasing and at present bear about an equal relation to each other. Some years the supply falls a little short and the prices go somewhat higher, with the result that larger quantities are imported. The following season the plantings are generally heavier, the market may be a little slow, and the result will be low prices and a great many people will discontinue the growing of onions.

Prices of onions, especially the Texas-grown Bermuda onions, are greatly influenced by importations of Egyptian onions which appear on our markets about the same time of the year that the Bermuda onions are being marketed. The ease with which both the Egyptian and the Spanish onions can be delivered to our eastern markets as compared with the long freight haul from southwestern Texas or Pacific Coast States renders the position of the American

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[3] For further information write to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

Bermuda onion grower more or less hazardous. Despite this condition, however, both the Bermuda and the Spanish onion industries have become well established in the United States. The American grower of Bermuda onions is still dependent upon the Canary Islands for his seed supply. In the case of the Valencia or Spanish onion, a part of the crop is grown from imported seed, but American seedsmen are now providing the greater part of the seed supply.

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March 27, 1930

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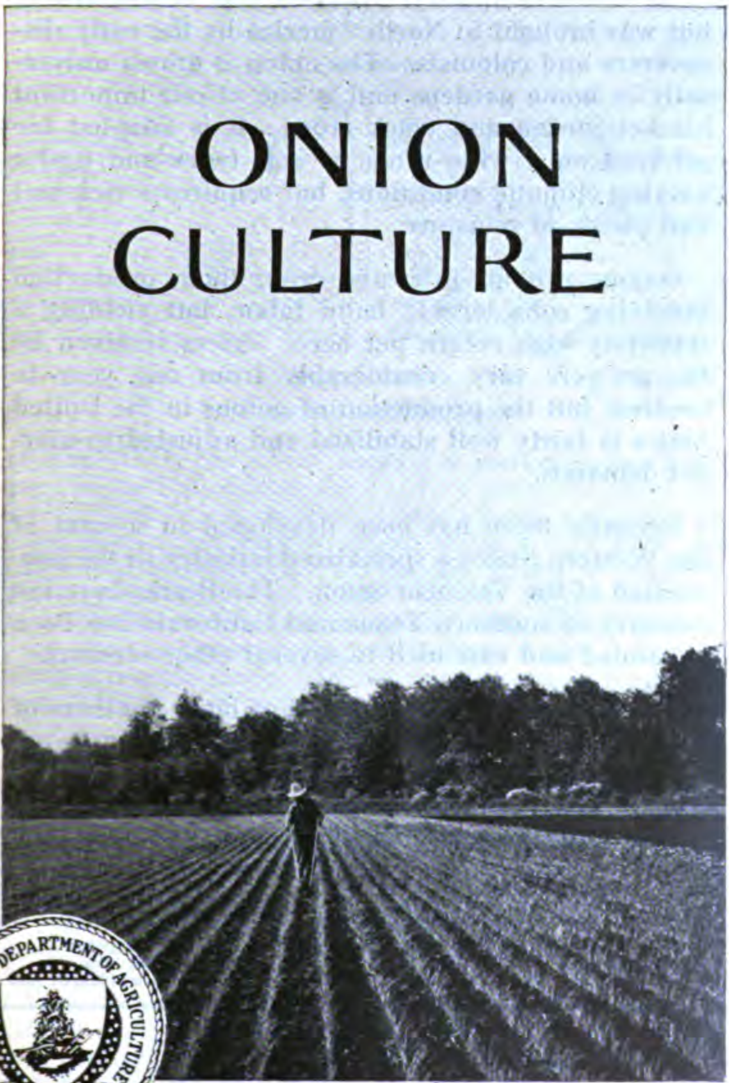
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 354

ONION CULTURE



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THE ONION, in one or more of its several forms, has been in use throughout all time of which we have authentic history. It is of Old World origin, but was brought to North America by the early discoverers and colonists. The onion is grown universally in home gardens and is one of our important market-garden and truck crops. It is adapted for growing on a wide range of soil types and under varying climatic conditions, but requires a rich soil and plenty of moisture.

Onions are an intensive crop, their production involving considerable hand labor, but yielding a relatively high return per acre. Prices received by the growers vary considerably from one year to another, but the production of onions in the United States is fairly well stabilized and adjusted to market demands.

Recently there has been developed in several of the Western States a specialized industry in the production of the Valencia onion. The Bermuda-onion industry of southern Texas and California has been expanded and extended to several other sections.

The production and shipment of large numbers of early seedling onion plants by southern plant growers has to a certain degree replaced the use of onion sets for planting in home gardens and for a portion of the northern early market crop.

Washington, D. C.

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ONION CULTURE

By W. R. Beattie, *senior horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

CONTENTS

Page
Introduction 1
Climatic requirements 2
Soils adapted to onion culture 3
Cultural methods 4
  Preparation of new land 4
  Crop rotation 4
  Preparation of the soil 5
  Fertilizers 6
  Planting 8
  Cultivation 11
  Irrigation 13
Harvesting and curing 14
Storage 17
Marketing 20
Commercial varieties 21
Production of Bermuda onions 22
  Soils and climate adapted to the Bermuda onion 22
  Cultural methods 23
  Harvesting and marketing 23
  Yield of Bermuda onions and prices obtained 23
Green onions for bunching 24
  Cultural methods 24
  Marketing 24
Diseases of the onion 25
Onion insects and their control 25
Present status of the onion industry 26

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INTRODUCTION

THE ONION is one of the important market-garden and truck crops in the United States and is very generally grown in home gardens. It thrives best on alluvial and drained muck soils under a temperate climate, but may be grown under a very wide range of soil and climatic conditions. Onions are grown to perfection on the alluvial soils of the Nile River Valley in Egypt, under the sea breezes of the South Sea Islands, on the delta lands along the seacoast, on sandy uplands, in the arid regions under irrigation, and on reclaimed swamp lands. There is perhaps no extensive area in the United States or its possessions where the onion, in one or more of its forms, can not be successfully grown, at least for home and local use.

The onion is of Old World origin and has been used as a food plant from the earliest historic times. It was an important article of diet in Egypt at the time of the building of the pyramids, and Moses, in his account of the exodus of the Children of Israel from Egypt, mentions it as one of the articles of food for which the Israelites longed during their sojourn in the wilderness.

Onions were brought to North America by the early discoverers and became one of the common crops of colonial gardens. Commercial onion culture in its present form has developed mainly during the last 40 or 50 years. Formerly the production of onions for sale was confined principally to the New England States, but the industry soon spread to other sections, and when the vast muck areas of the Great Lakes and other regions were drained and brought under cultivation the onion soon became one of the most important crops on these soils.

At present the principal commercial onion-growing centers are located in New England, especially in the Connecticut River Valley, in northern New Jersey, southeastern New York, the entire Great Lakes region, and as far west as Minnesota. The production of Creole onions centers around New Orleans, La., and the greater part of the Bermuda-onion crop is grown in southwestern Texas and in California. Within the last few years the production of the mild Valencia onion has developed in several of the Western States, including New Mexico, California, Arizona, Utah, Nevada, Washington, and Oregon. In addition there are many local areas in the United States where onions are being grown in considerable quantities for the market.

The production of several crops closely related to the onion, such as chives, shallot, leek, and garlic, has been developed around local centers, especially in connection with market gardening near the large cities. Garlic might be mentioned as an exception, because it is produced mainly in a few localities where soil and climate are especially suitable for its growth.

The present acreage and production of onions in the United States are about equal to market demands. During years of short crops and low yields there is a shortage of onions with consequent high prices, but during years of heavy crops the supply, as a rule, exceeds the demand, and frequently prices are too low for profitable returns to the grower.

CLIMATIC REQUIREMENTS

For best results a temperate climate without great extremes of heat and cold should be selected. Onion culture is rarely profitable in regions where the climate does not change or has no definite seasons of heat and cold or moisture and drought. The onion does best under rather cool conditions, with plenty of moisture during its early stages, but requires a reasonable degree of heat, together with dryness of both soil and atmosphere, for its proper ripening. Where the onion industry has become established in the extreme southern part of the United States, the growing season is during the late autumn and winter, the crop maturing during the spring and early summer. If the crop matures at a time when there is considerable rainfall, it will be impossible to cure the bulbs without artificial means and they will be lacking in keeping qualities.

Certain types and varieties of onions, including the top onions and the multipliers or potato onions, are extremely hardy and may remain in the open ground throughout the winters of our Northern States, especially if given slight protection. These types are, however, not adapted to growing for market, except as green onions, "peelers," or "bunchers," to be sold during the early springtime. In certain sections of the South Atlantic coast region large areas of the top and multiplier onions are grown for this purpose. There is also a marked difference in the temperature requirements of the standard commercial sorts, some being adapted to growing far northward, while others, like the Bermuda, Egyptian, and Spanish types, do best in restricted southern localities.

The period required for the production of a crop of onions will depend upon the season, the methods employed in growing, and the

variety. If grown from seed, a period of from 130 to 150 days will be required. If from sets, the crop often may be matured in 100 days. If grown in the extreme northern part of the United States, where the seasons are short, the crop will mature more rapidly than to the southward. In the case of the Bermuda onion, as grown in Texas, the growing season extends from October to the following March or April.

Onions require an abundance of moisture during the early stages of their growth, but should be ripened under comparatively dry conditions. In most sections the seed is sown at a time of the year when frequent spring rains occur. Their period of greatest growth is during the early part of the summer, and the crop is ripened late in the summer when drying conditions may be expected. In irrigated regions the application of water is almost entirely under the control of the grower. During the active period of growth the water is applied about once a week, the soil being thoroughly soaked and the surplus water drawn off.

The amount of rainfall or irrigation required for the production of a crop of onions will depend largely upon the character of the soil and its drainage. Many of the peat or muck soils in which the soil water remains near the surface will require very little rainfall; in fact, the best crops of onions are produced on these soils during seasons of comparatively light but evenly distributed rainfall. Sandy and loose soils generally will require a greater amount of water, especially during the early part of the season.

SOILS ADAPTED TO ONION CULTURE

The essential requirements of a soil upon which to grow onions profitably are a high state of fertility, good mechanical condition in order that the crop may be easily worked, sufficient drainage, and freedom from weeds. If a soil has the proper mechanical properties—that is, if it contains sufficient sand and humus to be easily worked, is retentive of moisture and fertilizers, and is capable of drainage—all other requirements can be met. At least three types of soil are being extensively planted to onions in this country, the one common essential being proper mechanical condition.

Clay and alluvial loam soils abound in the river valley and delta regions near the coast. These soils are generally very fertile, but may require the addition of humus or stable manure in order to lighten them. The greatest difficulty encountered in growing onions upon land of this character is the tendency of the soil to run together and bake after hard rains. This is especially injurious after the seed has been sown and before the small plants have attained sufficient size to permit of stirring the soil about them. Where these soils contain considerable sand they are ideal for onion culture. It is upon this class of soil that the greater part of the Bermuda, Spanish, and Egyptian onions are grown.

Sandy soils, especially where underlain by a well-drained clay subsoil, are often well adapted to onions. Soils of this character generally require heavy applications of fertilizers before they will produce a paying crop, but the quality of the product is excellent. Onions grown on sandy loams are generally solid, heavy, and of excellent keeping quality. Where sandy soils are lacking in humus

this may often be applied by means of crops of legumes grown upon the land and plowed under.

Throughout the north-central part of the United States there are vast tracts of peat or muck soils that are capable of producing onions. Before planting to onions, however, these soils must be cleared, drained, and brought to a suitable state of cultivation. In many cases this process will require two or three years' time, but sometimes the soil can be broken during the early winter, allowed to lie exposed to the action of frost, then worked down and planted to onions the following spring. Some of the largest onion farms are located on muck lands. The store of plant food in muck soil is usually large, but often it is not in available condition, and heavy applications of manure and commercial fertilizers, especially superphosphate and potash, are essential to profitable crops.

CULTURAL METHODS

The onion belongs to that class of crops which gives best results under very intensive culture, and the greatest yields are secured where a moderate acreage is planted and the work conducted in a most thorough manner. There is nothing technical about the growing of onions, but close attention and frequent cultivation are essential. Once the weeds get a start, the cost of production will be greatly increased, or the crop may be lost altogether.

PREPARATION OF NEW LAND

As a general rule new land is not adapted to onion growing until it has been worked one or two years with other crops. Onions should follow some row crop that has been kept free from weeds the previous season. Corn, beans, and potatoes are suitable crops with which to precede onions. Muck and sandy soils may in some cases be brought to a suitable condition for onions the first season, but the fitting will have to be very thoroughly performed. The land should be plowed in the autumn, then replowed in the spring, after which numerous harrowings and doubtless some hand work will be required to get the soil in suitable shape.

If necessary to manure the land heavily before planting to onions, it will be desirable to plant to some farm crop one season, then apply the manure during the autumn in order to give it time to become incorporated with the soil. Owing to the value of good onion land it would not be advisable to devote it to general farm crops for any extended period, although corn is frequently planted and oats or rye are sometimes used in the North. Cowpeas may be of great service in bringing new land into shape for planting to onions.

CROP ROTATION

Onions should not be planted on the same piece of land year after year, but some system of crop rotation should be maintained. Care should be taken, however, to use crops in the rotation that will not be exhaustive of the high fertility necessary in the onion land. During the years when the land is not devoted to onions it can be planted to some truck crop that will give a return that will justify the appli-

cation of large quantities of fertilizers, or, better, to a leguminous crop to be turned under as green manure. Continuous cropping with onions will cause the land to become infested with both disease and insect enemies that will sooner or later injure the crop to such an extent as to render it unprofitable.

PREPARATION OF THE SOIL

Assuming that the land intended for planting to onions is capable of being brought to a good mechanical condition, is fertile, well drained, and reasonably free from weed seeds, the first step in the production of the crop will be to plow moderately deep, then harrow, disk, roll, and drag until the soil is smooth and mellow to a depth of 5 to 7 inches. The method of preparing the soil will depend somewhat upon its character, the manner of planting to be followed, and the requirements for irrigation. There are few truck or other crops that require so careful fitting of the soil as do onions, and it is essential that the fertilizers be well mixed with the soil.

On soils that are naturally well drained and where surface water can not accumulate, the plowing may be done in large blocks, but where the opposite conditions are found or irrigation is practiced it may be necessary to plow the land in narrow beds. In the case of insufficient drainage it will be desirable to throw the soil into beds, leaving double furrows between the beds to carry off surplus water. Where the flooding system of irrigation is practiced the beds must be leveled and a system of ditches and ridges provided for distributing and controlling the water. Where it is merely desired to secure surface drainage the beds may be from 75 to 150 feet in width, but for irrigation purposes the beds are generally but 12 or 15 feet in width. If spring plowing is practiced the soil should be harrowed closely behind the plow in order to prevent drying out.

For cutting and pulverizing the soil there is perhaps no tool as serviceable as the disk harrow. There is a type of disk having four gangs, in two sets, one combination in front of the other and so arranged that the soil is first turned to the center and then turned outward again by means of the rear combination. This tool turns the soil twice and leaves it in a level condition. For smoothing and leveling the soil behind the plow a harrow of the type shown in Figure 1 is very desirable; this tool not only levels but turns and crushes the soil at the same time.

On land that has been plowed during the autumn and requires replowing in the spring, a device of the type shown in Figure 2 will answer and will do the work more rapidly than the plow. This tool is especially adapted to bedding up land that has been previously plowed.

For imparting the final smoothing touch to the soil before planting there is a device consisting of a large number of small disks set in a wooden frame (fig. 3) which does about the same work as a steel rake, but in a rapid manner. A drag or float made from several pieces of scantling nailed together may be used for this purpose, or if the soil is very loose a roller should be run over it. The final leveling should be performed with a tool that will fill and obliterate all tracks or other depressions in the soil, leaving a smooth, even seed bed for either seed sowing or transplanting.

FERTILIZERS

As the onion is an intensive crop and should yield great quantities of marketable bulbs for the area planted, the grower is justified in fertilizing heavily. It would be difficult indeed to make the soil too rich for onions, provided the manures are thoroughly incorporated with the soil. A heavy application of fresh raw manure just before planting would have an injurious effect, but where the manure is well rotted and uniformly applied there is nothing to be feared.

ANIMAL MANURES

There is perhaps no fertilizer so well adapted to the production of onions as plenty of disease-free, well-composted stable manure, and the quantity and frequency of application will depend upon the nature of the land under cultivation. The Bermuda-onion growers of southwestern Texas apply as high as 20 tons of sheep and goat manure to an acre every three years. In addition to the manure there is used 1,000 to 2,000 pounds of cottonseed meal or commercial fertilizer, and sometimes a top-dressing of nitrate of soda. This sheep and goat manure, from animals that are fed largely on cottonseed meal, is saved in the corrals in a climate where there is very little rain, and contains the essential fertilizing ingredients in very high percentages. The manure is first piled where a little water can be thrown over it and it is composted for several months before spreading on the land. The best results from this manure are not realized until the second or even the third year after its application.

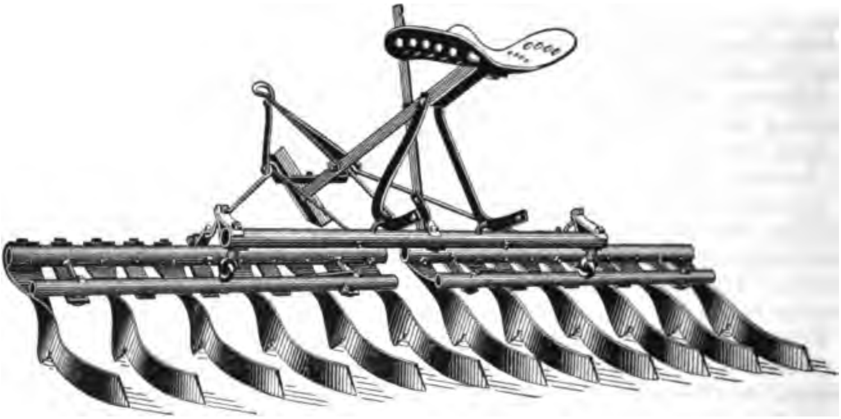

FIGURE 1.—Harrow for smoothing and leveling the soil behind the plow

All stable manure used on onion land should be well composted before use and then spread upon the land several months before planting to onions. In the Northern States the manure may be applied during the autumn and well disked into the soil. The land can then be allowed to lie in the rough state and exposed to the action of frost during the winter, or it can be smoothed and seeded to rye, in which case it will be necessary to replow early in spring. In the Bermuda district the manure should be applied during the

spring and the land kept frequently stirred during the summer, with occasional irrigations in order to incorporate the manure and destroy weeds; the planting is not done until the autumn. Another practice in the Bermuda district is to apply fresh manure broadcast at the rate of 10 to 12 tons to the acre during the spring, then plant to corn and cultivate through the early summer, and add a top-dressing of well-rotted manure after plowing the land for onions in the autumn. This top-dressing should be well worked into the soil by means of disk harrows. Large quantities of fresh manure applied on onion land just before planting will have a tendency to produce an overgrowth of tops at the expense of the bulbs. This is especially true on irrigated lands and soils that are naturally moist.

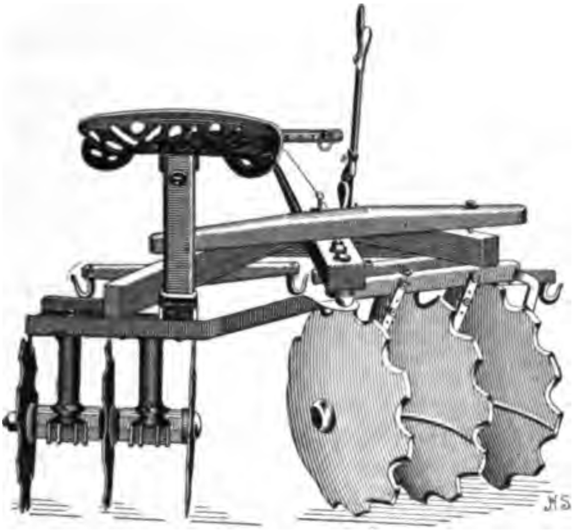

FIGURE 2.—Disk plow used for refitting land

COMMERCIAL FERTILIZERS

A fertilizer that is suited to the growing of potatoes will serve quite well for onions, but the potash should perhaps be supplied in the form of muriate rather than of sulphate. A fertilizer adapted to the growing of onions should contain 4 to 5 per cent of nitrogen, 8 to 10 per cent of phosphoric acid, and 8 to 10 per cent of potash.

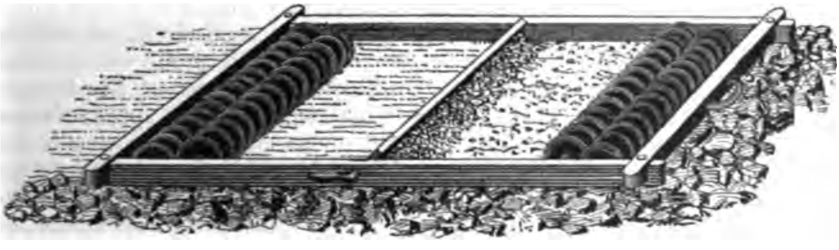

FIGURE 3.—Device used for smoothing soil before seeding

A fertilizer of this character will cost $40 to $45 a ton and can be profitably applied at the rate of 1,000 pounds to the acre on most soils. Where very intensive cultivation is practiced it may be profitable to apply as much as a ton to the acre in addition to stable manure.

Commercial fertilizers should be applied shortly before sowing the seed and should be uniformly distributed and thoroughly worked into the soil. There are fertilizer distributors that scatter the fertilizer broadcast, but where an amount not exceeding 1,000 pounds of fertilizer to the acre is being used the work of distribution may be performed by means of a common grain drill having a fertilizer attachment. On a small scale the work is generally performed by hand.

Many growers follow the practice of applying only a part of the fertilizer at planting time, reserving the balance to be put on as a top-dressing at some time during the period of cultivation. This plan is especially desirable where onions are grown during the winter, as the application of highly nitrogenous fertilizers in the autumn is liable to promote a soft growth that will be injured by cold. If the fertilizer is not put on until cold weather is over, the crop may be forced without danger of injury. For this purpose only those fertilizers of a very available form will answer. Nitrate of soda is frequently used as a top-dressing during the height of the growing period.

PLANTING

Most of the onions grown in the United States are started from seed. Propagation from seed is conducted by three more or less distinct methods: (1) By sowing the seed in the rows where the crop is to grow and mature; (2) by sowing the seed in specially prepared beds and transplanting the seedlings to the open ground; and (3) by first growing sets from seed and then, after keeping them through the winter, planting them in the field to produce the crop of mature bulbs. Of these three methods the one first mentioned of seeding in the rows where the crop is to mature is the one most used on a very large scale.

SEEDING IN ROWS

In the northern onion-growing districts the seed is sown as early in the spring as the soil can be brought to the proper condition. While it is desirable to plant quite early, it never pays to sow the seed before the land is in the best possible condition. When the soil has been brought to a smooth, even surface and is fine and mellow, the seed is sown by means of a common seed drill, of which there are several makes on the market. The hand drills which sow one row at a time are extensively employed, but many of the larger growers employ a gang of drills hitched together and plant from five to seven rows at once. In heavy or moist soils the depth to cover the seed should not be more than one-half to three-fourths inch, while on loose and sandy soils the seed may be covered about an inch.

Where hand cultivation is practiced throughout, the usual distance between rows is 12 to 16 inches. Where horse culture is employed the distance between rows varies between 24 and 36 inches. The quantity of seed required to plant an acre will depend both upon the distance between rows and the purpose for which the onions are being grown. For the growing of standard market onions in rows 14 inches apart, about 4½ pounds of first-class seed will be required. With the rows 3 feet apart, but 1¼ to 1½ pounds will be necessary. Where it is

desired to produce small onions for pickling purposes, the amount of seed may be as great as 25 pounds to an acre. Good seed is essential, and if there is any doubt regarding the vitality of the seed it should be tested before planting by counting and planting 400 or 500 seeds in a window box and then determining the germination by counting the seedlings after 10 days' or 2 weeks' time. First-class seed is seldom sold at a low price and good seed at $1.50 or even $2.50 a pound may be cheaper in the end than poor seed at 50 cents. Old and inferior seeds are not only low in percentage of germination, but lack the vitality necessary to produce strong, healthy plants. There are dealers who make a specialty of securing and furnishing extra-quality onion seed, and while their prices are often somewhat above the general market the seed furnished by them is preferable to ordinary seed.

Experienced growers are able by using extreme care in regulating the drills to distribute onion seed in rows where the crop is to mature so that little thinning will be necessary. Thinning is generally left until the time of the first hand weeding, when all thick bunches along the rows are thinned to a uniform stand of 8 or 10 plants to the foot. It is always well, however, to allow for considerable loss of plants, and unless the plants are so thick as to actually crowd, thinning will not be necessary.

TRANSPLANTING METHOD OF GROWING ONIONS

The transplanting process is merely a modification of the regular seeding method. The objects gained by transplanting are an earlier crop, a uniform stand, and bulbs of more regular size. Practically the entire crop of Bermuda-type onions grown in the United States is handled in this manner. Where a small area is to be grown, the transplanting process is the ideal method, but for large acreages where labor is difficult to obtain this would not be practical. After transplanting, the seedlings will require rain or watering, and for this reason the transplanting process is practically limited to areas where some form of irrigation is available.

In growing onions by the transplanting method the seed is sown in greenhouses, hotbeds, coldframes, or specially prepared beds at the rate of 3½ or 4 pounds for each acre to be planted. Onion seedlings are now being grown in great quantities by southern plant growers and are shipped to northern onion growers. When the seedlings are grown under cover, they are given the necessary attention regarding watering and ventilation and kept growing quite rapidly until near the time for setting them in the open ground. As planting time approaches, the seedlings are "hardened" or prepared for transplanting by increased ventilation and exposure and by withholding water. When ready to transplant, the seedlings should be somewhat smaller than a lead pencil and rather stocky. The plants are lifted from the seed bed and the roots and tops both trimmed somewhat, as shown in Figure 4. They are then packed neatly in shallow boxes for removal to the field where they are to be planted.

Various methods are employed for handling the plants in setting. As a rule, a line is used and the land marked to indicate the location of rows. Several methods are employed for marking the distance

between plants in the rows. A marking device much used by the Bermuda-onion growers in Texas consists of a sectional roller with the sections the same distance apart as the distance between the rows and each section provided with conical pins to form the holes in which the plants are set. The objection to the sectional roller marker is that it can not easily be drawn in a straight line and straight rows are essential to good cultivation.

After marking the land, the plants are dropped ahead of the planters, or they may be kept in the trays and simply removed as planted. The transplanting process consists mainly in pushing the root end of the seedling into the soil with one finger and then firming the soil about the plant. This work is very laborious and can only be performed economically by very cheap labor. A small plow, such as is generally included with the attachments of the wheel hoe (fig. 5), is often employed for opening a furrow in which to set the small onion plants. As the plants are set the soil is either drawn about them by hand, or the plow may again be used for this purpose. In the Bermuda-onion district the work of transplanting is as a rule done by contract. In transplanting, all inferior plants should be rejected, thus insuring a more nearly perfect stand and development.

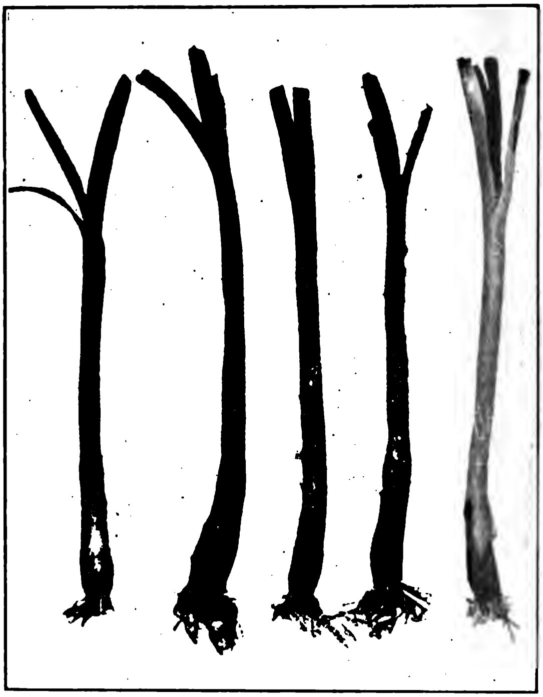

FIGURE 4.—Seedling onion plants trimmed ready for transplanting

PROPAGATION BY SETS

The use of sets is still another modification of the regular seedling method, in which the seed is planted one year to form the sets from which to grow a crop of mature onions the following year. Like the transplanting process the use of sets is limited in its application. Onions grown from sets will ripen earlier than those from seed sown in the field, but the use of sets for commercial onion growing is not so practical as transplanting seedlings, because of the high cost of sets. In planting onion sets a furrow about 2 inches deep is opened, the sets being dropped about 3 inches apart and firmly covered. The quantity of sets required to plant an acre will depend upon their individual size and planting distances, but it is generally between 15 and 22 bushels.

CULTIVATION

The cultural requirements of the onion are frequent shallow stirring of the soil and freedom from weeds. The feeding roots of the onion run close to the surface of the soil and should not be disturbed by deep cultivation. Sometimes a heavy rain immediately after seeding will so pack the surface that the seedlings can not break through. Under such circumstances it will be necessary to slightly break the surface by means of a steel rake or a rakelike attachment on a cultivator. As soon as the plants are up and the rows can be followed the cultivator should be started to loosen the soil, which is always more or less compacted during seeding.

HAND CULTIVATION

Where the rows are 14 inches or less apart, the work of caring for the crop must all be done by hand. For this purpose the wheel-hoe tools of various types are essential. These implements are provided with several kinds of hoes, cutters, and sweeps designed to work the soil away from the plants, to shave the surface and destroy weeds, and to stir the soil and work it back around the plants. Onions grown on muck and alluvial soils will require from 8 to 14 workings with the wheel-hoe implements; on sandy soils it will not be necessary to cultivate so frequently.

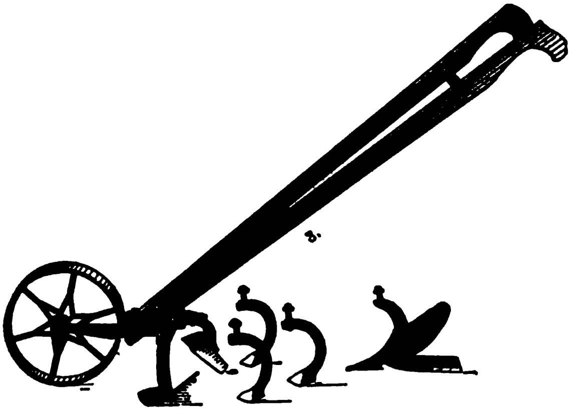

Figure 5.—Wheel hoe adapted to working onions

Several types of wheel hoe are in use, but those having a single wheel and passing between the rows are most desirable. Those of the type shown in Figure 5 are good. Many growers have designed special implements to suit the requirements of their soils; two of these are shown in Figure 6, the one designed to cut the soil away from the row and the other to stir and work the soil back to the row. Some of the growers in the onion fields near Chicago have adopted a hoe stock consisting of a pair of light plow handles, an iron stock, and the front wheel of a bicycle. To the stock of this device may be attached almost any form of sweep or cutter, and the implement is exceptionally easy to propel. The wide distance between the handles places the implement well under the control of the operator. Figure 7 gives an idea of the general appearance of this implement.

HORSE CULTIVATION

In sections where onions are grown on a soil that is not well adapted to hand culture the rows are placed 30 to 36 inches apart

and the cultivation is performed by means of horse-drawn tools. This is particularly true where onions are grown on the black waxy soils of Texas and other soils of the prairie type. As with hand culture, frequent shallow stirring of the soil is essential, the work generally being performed with one of the harrow-tooth cultivators. Those of the type shown in Figure 8 are well adapted to this work. An implement known as a weeder can be used for breaking the surface before the seedlings appear; also for general cultivation by removing a tooth at the point where the rows are located.

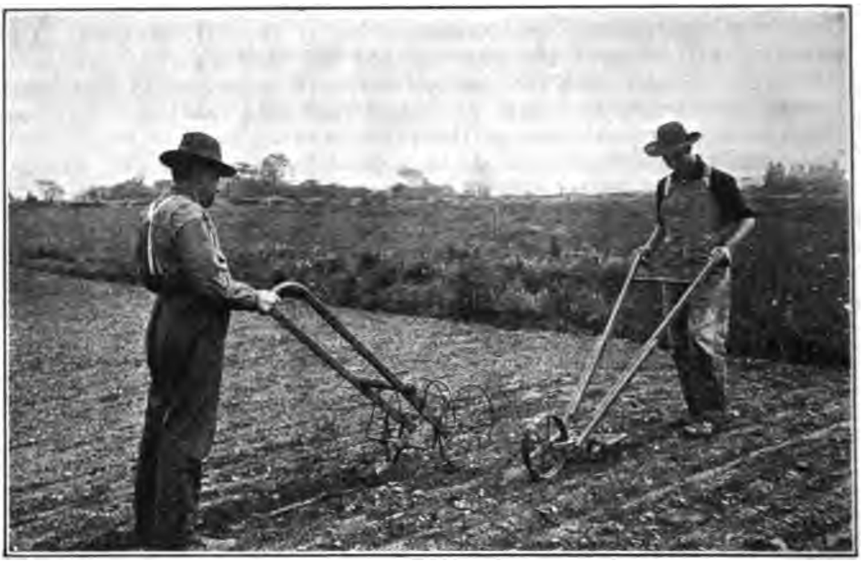

FIGURE 6.—Special wheel hoes for cultivating onions

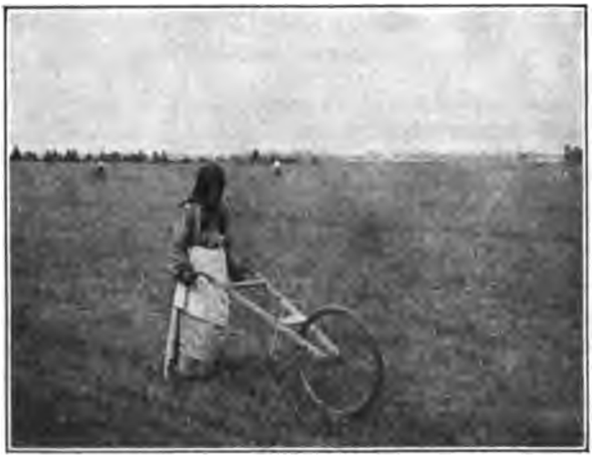

FIGURE 7.—High wheel type of hoe. (Patented)

HAND WEEDING

It is well-nigh impossible to produce a crop of onions without some hand weeding. During favorable seasons the strictly handwork may be reduced to but one or two weedings, but a greater number will be necessary during rainy seasons. Each hand weeding will cost from $5 to $12 an acre, according

to wages paid and the number of weeds present. The work of hand weeding may be facilitated by the use of some of the small hand tools designed for the purpose. Among these tools might be mentioned the onion hoe (fig. 9), the hand weeder (fig. 10), and the thinning or weeding hook (fig. 11). Girls and boys are expert at hand weeding, the practice being to work them in gangs of 10 to 20 with an overseer behind them to see that the work is properly done. In some localities the wages paid for this class of work are $1.50 to $2.50 a day.

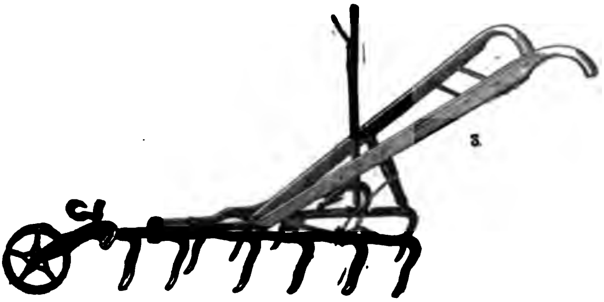
FIGURE 8.—Small-tooth horse cultivator

IRRIGATION

Outside of the areas where irrigation methods are depended upon for the production of general crops it is not customary to use artificial watering in the growing of onions. In a few cases the land has been equipped with overhead sprinkling systems which are employed to moisten the soil after the seed is planted and also during extremely dry weather. On peat and muck soils the young seedlings are frequently lost by the dry muck blowing with the high winds of early spring. In this way a part of the field may have the soil blown off to such an extent that the plants will be left without soil about them, while other portions of the field will be covered by 1 or 2 inches of loose muck. The use of a small quantity of water sprayed over the field will sometimes prevent this shifting of the soil during a windstorm but will not prevent the accumulation of muck blown on to the plants from adjacent nonirrigated areas. Sandy soils are also subject to the action of winds to a greater or less extent, and losses may be prevented by the timely application of water over the surface. In a few instances subirrigation is employed in the growing of onions.

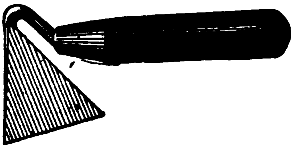
FIGURE 9.—Onion hoe

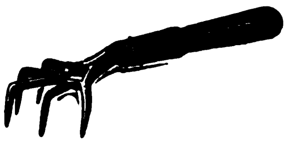
FIGURE 10.—Hand weeder

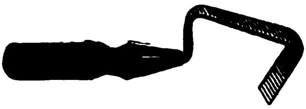
FIGURE 11.—Thinning or weeding hook

Throughout the Bermuda district of the Southwestern States surface irrigation is almost universally employed. The Bermuda onions are planted mostly in comparatively level beds with dividing ridges and are flooded once each week or 10 days during the growing period. About a week before the plants are set the soil is flooded

and then worked over with disk and smoothing harrows just ahead of the planters. Within a day or two after planting the land is again flooded and the surface water drawn off; this process is repeated, with alternate cultivations, as often as required. Toward the end of the growing season the water is withheld to allow the bulbs to ripen. As a rule about 10 waterings in all are required, at a cost of about $2.50 an acre for each watering, or $25 per acre altogether. Figures 12 and 13 give a good idea of the methods of applying the water in the Bermuda-onion growing district.

In the principal Bermuda-onion growing districts the water for irrigation purposes is obtained only after the expenditure of thousands of dollars for pipe lines and pumping machinery. The cost of watering as given above does not include any share of the original cost for installation or water charges, but covers only the labor.

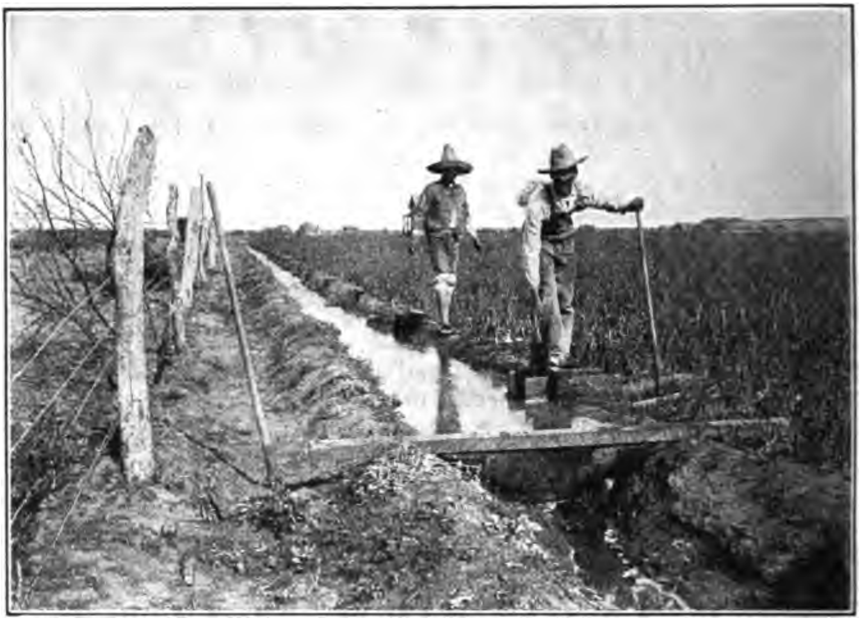

FIGURE 12.—Irrigation ditches in Bermuda-onion field in Texas

HARVESTING AND CURING

In the northern onion districts the crop ripens and is harvested during the latter part of the summer and early autumn. As a rule the work of harvesting onions begins late in July and is practically completed and the crop housed before October. In the Southern States, where the crop is grown during the winter, the harvesting and marketing period is during the spring and is practically ended before the northern product comes upon the market.

In the North the bulbs are allowed to become as ripe as possible before removing them from the soil. Growers prefer that the tops

ripen down and shrivel and that the outer skin of the bulbs be dry before they are pulled. Figure 14 shows a field of onions in prime condition for gathering. To the southward, where the onions are not cured so thoroughly, they are often pulled about the time that the tops begin to break and fall. The ripening process often may be hastened by rolling a very light roller or a barrel over the tops to break them down. This process is frequently spoken of as "barreling."

Where the bulbs are practically upon the surface they may be pulled by hand and thrown in windrows consisting of 8 or 10 onion rows. If the onion bulbs are considerably covered with soil it will be necessary to employ a 1-horse plow or a cultivator with a sweep attached for lifting them. In any case it will be necessary to gather them from the soil by hand. After lying in the windrows for several days and being stirred occasionally with wooden rakes, the tops are removed either by twisting or cutting with ordinary sheep shears. In cases where very bright color is important, as with fancy White Globe onions, and this would be injured by exposure to the sun and rain, the bulbs are cured in long, narrow, low ricks formed by placing several rows of onions laid with the bulbs to the center and the tops to the outside to protect the bulbs. As the tops are removed the bulbs are generally placed in crates for drying. Onion-topping machines frequently are employed, the bulbs being hauled from the field to a central location and run through the topper. These machines remove the tops, grade the bulbs, and deliver them into the crates or bags. If crates are not employed for curing, the bulbs are allowed to lie in the windrows for some time, and are then either

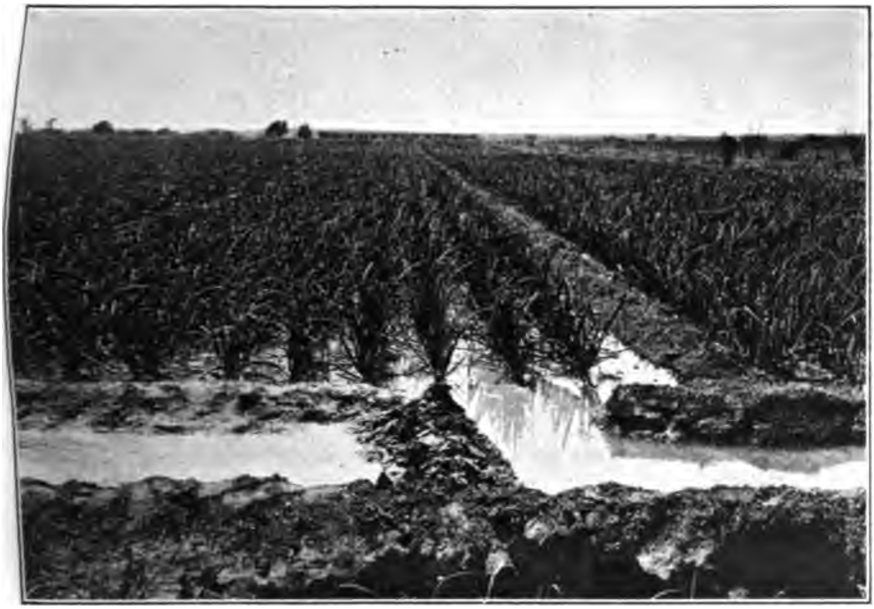

FIGURE 13.—Irrigation of Bermuda onions in Texas

put into sacks or hauled to slat cribs, where the curing process is completed. Too long exposure to hot sunshine will injure the bulbs. Figure 15 shows a field of onions drying in windrows, with crates ready for their removal from the field.

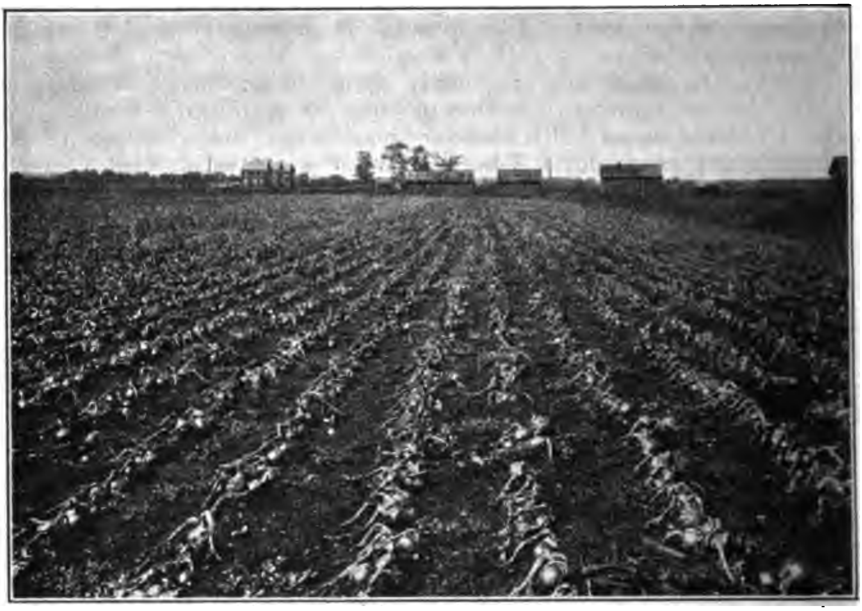

FIGURE 14.—Field of onions in condition for gathering

After gathering into crates, the crates are either stacked in the field, hauled to a central stacking yard where they are covered with boards or canvas, or hauled to open sheds and there piled one upon the other with numerous air spaces until the onions are thoroughly cured.

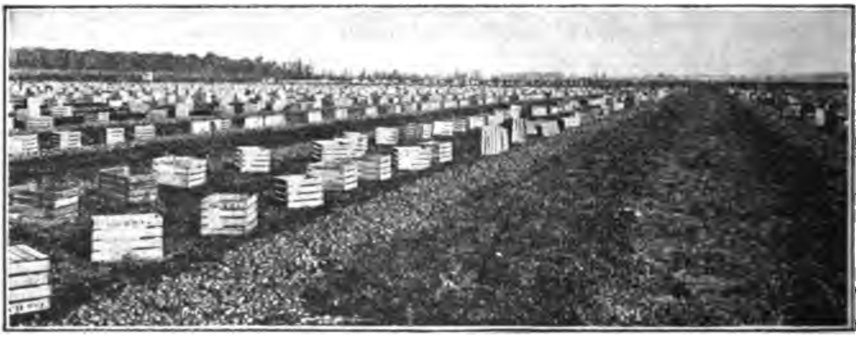

FIGURE 15.—Onions drying in windrows, showing crates used for curing and storing

Where the bulbs are extremely dry at the time of their removal from the soil, they may be allowed to lie in the windrows for a few days only, and then sorted and cleaned in the field ready for packing and marketing. Where onions are put into sacks and afterwards

allowed to remain in the field, the sacks should be supported on poles laid on the ground, as shown in Figure 16.

In the Bermuda-onion districts, where only a short curing process is given to the crop, it is the practice to pack and load into the cars as soon as possible after pulling and topping. When the shipping is at its height, it is not uncommon for onions that are pulled from the soil in the morning to be in the cars and on their way to market by evening; however, a portion of the crop is given a more thorough curing process, and the entire crop would be benefited by at least two days of curing before shipment.

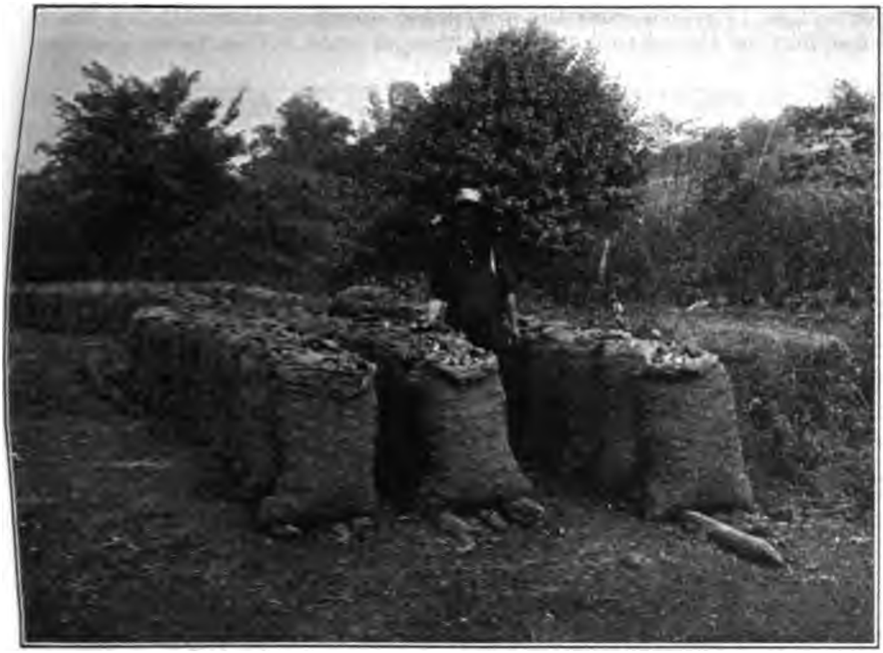

FIGURE 16.—Method of curing onions in sacks standing in the field

STORAGE

In order that onions should keep well when stored they must be well ripened and thoroughly cured. "Thick necks" or those that are immature, or soft, should never be placed in storage but should be sold as soon as gathered for whatever price they will bring. Good storage onions will rattle almost like blocks of wood when poured from one crate to another. In order that the bulbs may remain bright and of attractive appearance they should not be allowed to lie exposed to the weather, but should be hauled and stored in open sheds just as soon as they may safely be placed in 1-bushel crates.

After the bulbs have remained in drying sheds or cribs for four or five weeks they will be ready for screening and removal to the storehouse. In handling onions it is the rule to pass them over a screen each time they are moved, as in this way the loose skins are removed and any soft or decaying bulbs may be sorted out. When bags are

used for drying in the field, the onions are screened in the manner shown in Figure 17, and the bags refilled for hauling to the storage house.

The essentials for the successful storage of onions are suitable containers, plenty of ventilation, a comparatively low temperature, dryness, and safety from actual freezing. Any building wherein the above conditions may be secured will answer, but houses of the type shown in Figure 18, which are built especially for the purpose, are most satisfactory.

The construction of the storage house should be double throughout, with plenty of felt or paper lining. Both top and bottom ventilation should be provided, and the ventilator openings should have doors that may be closed to control the temperature. The floors are constructed of narrow planks with half-inch spaces between the planks for the passage of air. Bottom ventilation is frequently secured by means of drainpipes built into the foundation at the surface of the ground. These pipes are carried some distance toward the center of the house and discharge the cool air at a point where it is most needed.

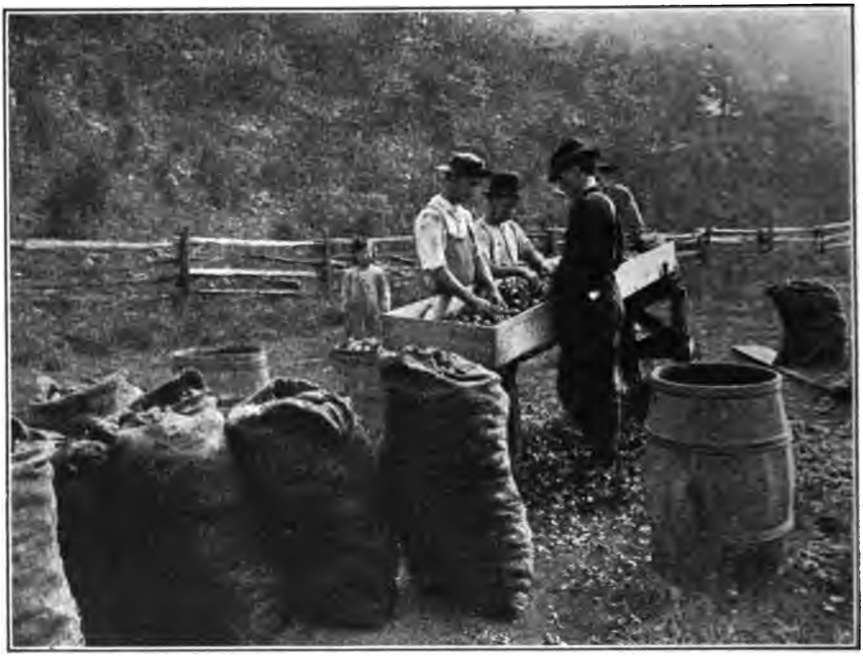

FIGURE 17.—Grading onions in the field by means of a screen

The temperature of the storage house should be carried as low as possible without actual freezing. During extremely cold weather the ventilator openings and doors should be kept closed to keep out cold air, and after the onions have become thoroughly chilled the house should be kept closed in order to hold the temperature down and prevent the entrance of moisture during warm or rainy periods.

Damp, foggy weather is injurious to onions, especially if it follows a period of cold, and will cause the bulbs to become covered with moisture if the outside air is admitted. A little artificial heat from a stove or radiator may be required during excessively cold weather, but so long as the temperature in the house does not fall below 32° F. there will be no danger of injury. A temperature of 36° to 38° will give good results.

The best method of storing onions is in standard-size slat crates 20 inches long, 16 inches wide, and 14 inches deep, outside measurements. The material for the sides and bottom is about three-eighths inch thick and 2½ inches wide, four pieces being used to form a side. The corners are reinforced on the inside by means of 3-cornered pieces of oak, to which the slats are nailed. These dimensions provide crates that are interchangeable, the width of five being equal to the length of four. The crates will also nest together when empty, with one inside of two turned together. The full crates are stacked in the storehouse with 1 by 3 inch strips between them to allow for the circulation of air, as shown in Figure 19.

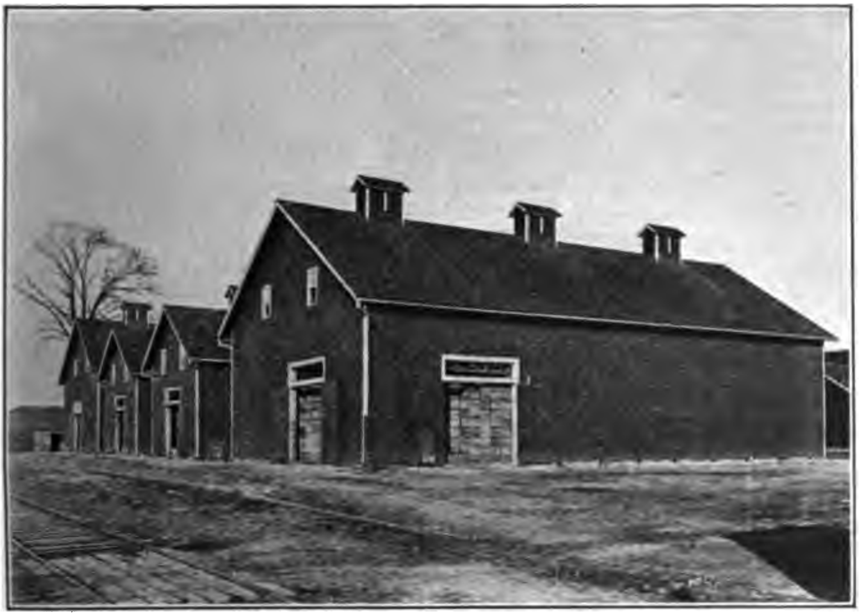

FIGURE 18.—Onion storehouses

Onions are sometimes stored in slat bins holding 100 to 300 bushels each. Bags are also used to some extent, but neither bags nor bins are as satisfactory as the crates, on account of the difficulty in providing the necessary ventilation and change of air through the onions. Bulbs stored in bags or bins must be more thoroughly cured than those stored in crates. There are single large storehouses in use that will accommodate 50,000 to 60,000 bushels of onions when stored in crates.

MARKETING[1]

Large quantities of onions are sold and shipped direct from the fields where they are grown. A part of the crop is held in temporary storage until late autumn or early winter. During recent years the winter storage of onions has become of great importance, and the finest stock is held for late-winter deliveries. The Bermuda crop from the southwestern part of the country comes on the market during April and May, so that most of the storage onions are disposed of before that time.

In marketing onions the first essential is to properly grade and clean the bulbs, in order that they may present an attractive appearance when offered for sale. Ordinarily the bulbs are separated into three grades—primes, seconds, and picklers. The primes include all of those 1¼ inches in diameter and larger, and the seconds consist of those from three-quarters of an inch to 1¼ inches in diameter, while all those that will pass through a ¾-inch screen are sold for pickling purposes. The grading is generally done in the field during the cleaning process, but as onions shrink considerably while in storage it is necessary to regrade before placing upon the market. The type of screen used for grading onions is shown in Figure 20. For cleaning the pickling onions an ordinary fanning mill is employed, special screens being provided for the purpose.

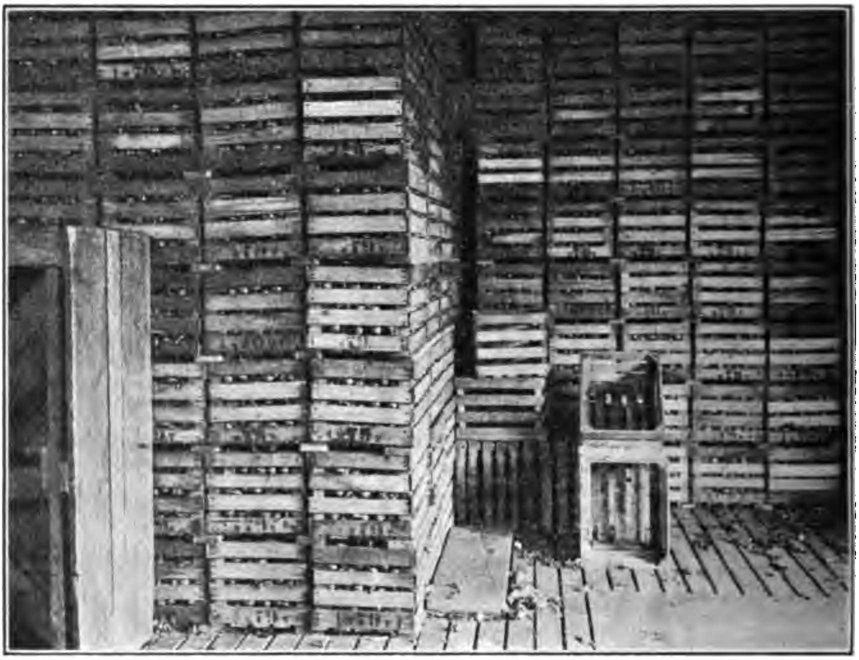

FIGURE 19.—Inside of storage house, showing method of stacking crates

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[1] For detailed information on the marketing of onions, see the following: United States Department of Agriculture Bulletins No. 1283, The Marketing and Distribution of American-Grown Bermuda Onions, and No. 1325, Marketing Onions. No. 1325 is out of print, but may be consulted in libraries.

Onions are placed upon the market in 1-bushel crates, bags, barrels, 1-bushel hampers and baskets, and in bulk. The folding crate, shown in the foreground of Figure 20, is undoubtedly the most attractive package in use for marketing onions. The bags employed are of special open-mesh weave and hold 100 pounds. Onions are sometimes shipped loosely in cars and shoveled into barrels or bags at their destination.

The legal weight of dry onions is generally considered 56 pounds to the standard bushel, although this varies somewhat in different States.

COMMERCIAL VARIETIES

For trade purposes onions are divided into two classes as "strong" onions and "mild" onions. The strong onions include the greater part of those grown in the northeastern United States and constitute the main storage and winter-marketing crop. This group includes such varieties as Yellow Danvers, Yellow Globe Danvers, Southport Yellow Globe, Ohio Globe, Japanese or Ebenezer, Australian Brown, and Red Weathersfield. The mild-flavored group includes the Red Bermuda, White Bermuda, Crystal Wax, Valencia, Sweet Spanish, and others.

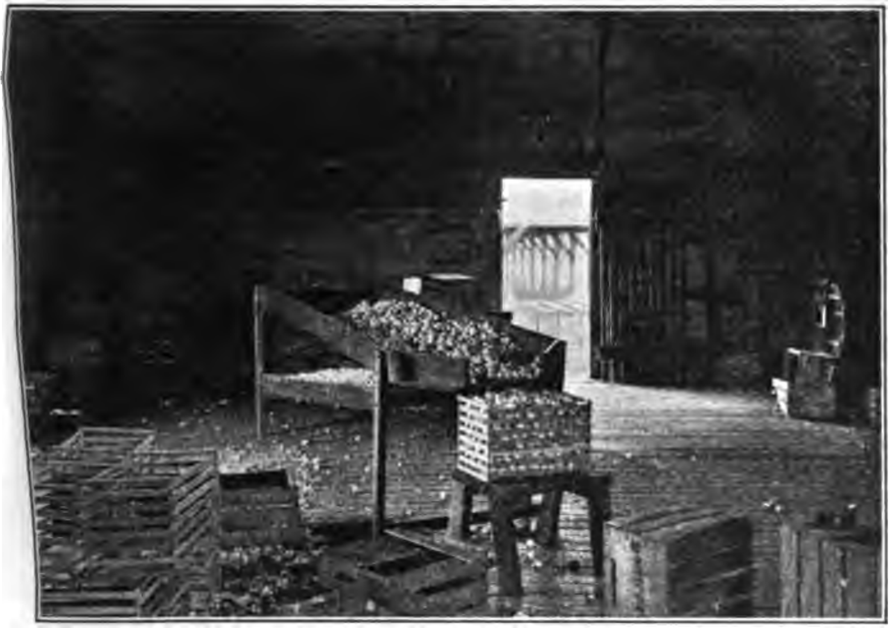

FIGURE 20.—Screen used for grading and cleaning onions, showing folding crates sometimes used for marketing

In the selection of varieties for any particular locality the soil and climatic conditions and market requirements should both be considered. Those adapted to the muck soils are the yellow and red sorts. For alluvial and prairie soils the red and brown varieties are to be preferred, while all kinds do well on the sandy loams and light soils. A cleaner, better grade of white onions can generally be pro-

duced on light or sandy soils than on muck or clay loams. Those of the Bermuda, Spanish, and Egyptian types flourish on the deep, rich alluvial soils of the river bottoms and delta regions.

Certain of our markets show a decided preference for onions belonging to a particular type. The red and brown varieties find ready sale on the markets of the Middle West, while onions of the yellow and white varieties are preferred in the eastern cities. Onions will withstand long-distance shipment, those of the mild type being generally more subject to injury than the strong sorts. Some of the white varieties also have a thin skin and are easily injured. It should be the aim of every grower to employ varieties that will withstand handling and at the same time find ready sale on the market.

The top or tree onion, which reproduces by means of small bulblets formed on the top of the seed stalk, is extensively used in the production of early-spring bunching onions.

The multiplier or potato onion reproduces by a division of the bulbs. In growing this variety it is necessary to plant large bulbs to produce sets for the next year's planting and small bulbs or sets for the crop of large onions. The bulbs of this variety may remain in the soil year after year and are desirable for use early in spring.

Garlic is closely allied to the onion, but will remain in the ground from one year to another in a mild climate if undisturbed. Garlic is planted by setting the small bulbs, or cloves, in either the autumn or early spring. The culture is practically the same as for the onion.

The leek also belongs to the same class as does the onion, but requires somewhat different treatment. The seed is usually sown in beds and the plants transplanted about 4 inches apart in the row. The plants of the leek are given about the same cultivation as onions, except that after they have attained almost full size the soil is drawn around them to a height of 6 or 8 inches to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored in cellars for winter use.

PRODUCTION OF BERMUDA ONIONS

Bermuda onions are now an important commercial crop in Texas and California, with small plantings in a number of the Southern States. The Bermuda onion fields of Texas are located around Laredo and other points in or near the Rio Grande Valley.

SOILS AND CLIMATE ADAPTED TO THE BERMUDA ONION

Soils of a silty or alluvial nature are suited to the production of Bermuda onions, and those containing considerable sand are most desirable. As already noted in referring to fertilizers for onions, the Bermuda requires a very rich soil for the best results, and this can only be obtained by first selecting a good soil and then manuring heavily. The Bermuda onion as grown in this country is a winter crop; therefore, mild climatic conditions are required. While the plants would withstand considerable freezing, their growth is seriously checked by cold weather, and the crop will not mature in time for the early market if grown to the northward.

CULTURAL METHODS

The cultural methods employed in the growing of Bermuda onions are essentially the same as those for ordinary onions. As the greater portion of the crop is grown in a region which has no regular rainfall, irrigation methods are employed almost universally. The greater part of the crop is grown by the transplanting process and a great amount of hand labor is required. The seeds are sown in specially prepared outdoor beds from the middle of September to the middle of October, and the seedlings are transplanted to the field November 20 to January 10, or even later. From 3½ to 4½ pounds of seed are required for each acre to be planted; this will allow for discarding all the weaker plants. The plants are allowed to remain in the seed bed until they are from three-sixteenths to one-fourth inch in diameter before they are transplanted. As the seedlings are lifted the greater portion of both the small roots and the tops is trimmed off in order that they may be transplanted more readily. (Fig. 4.)

HARVESTING AND MARKETING

Bermuda onions are harvested as early as possible, generally before the tops have become fully ripened. For removing the bulbs from the ground a 1-horse plow, a potato digger, or a cultivator with a cutter wing attached is employed. The bulbs are then separated from the soil by hand, the tops cut off with shears, and the onions thrown in windrows or piles to dry in practically the same manner as for the regular-crop onions in the North. After the bulbs have become thoroughly dry on the surface they are either placed directly in the crates for shipment or are carried to a packing shed to be graded and packed for market.

During the early days of the Bermuda-onion industry the crop was shipped largely in bags, but it was soon found that the bulbs were too perishable for this method of handling. At present the greater portion of the crop is sent to market in folding slat crates that are about 20 inches long, 12 inches wide, and 12 inches high.

These crates hold approximately 50 pounds of onions and weigh 56 or 57 pounds when filled. The cost of these crates is about $20 a hundred, but they add enough to the attractiveness and carrying qualities of the onions to make their use profitable.

YIELD OF BERMUDA ONIONS AND PRICES OBTAINED

Phenomenal yields of 34,000 and 35,000 pounds of Bermuda onions are frequently made on an acre of land, but this is far above the general average, which is in the neighborhood of 10,000 or 12,000 pounds to the acre. Many fields, especially when planted for the first time, do not yield as much as 10,000 pounds to the acre. On land that has been heavily manured and planted to onions for several years the yield averages about 16,000 pounds.

The best Bermuda-onion farms are valued at $300 to $500 an acre. In order to prove profitable, the growing of Bermuda onions should be conducted on a comparatively large scale. The necessary land and irrigation facilities will require the initial outlay of from $10,000 to $30,000, and the running expenses are quite heavy. Labor can be

secured at a low price, but is correspondingly inefficient and often not to be had in sufficient quantities. Furthermore, the markets are now pretty well supplied with Bermuda onions, and persons who desire to engage in their production are advised to investigate every phase of the industry before embarking too heavily in it. The expansion of the Bermuda-onion industry is limited by the facts that a large supply of bulbs can be grown on a comparatively small area, that the distance to market is great, that the product is perishable, and that the markets will consume only a limited quantity at the prices at which the crop can be sold with profit.

GREEN ONIONS FOR BUNCHING

Another phase of onion culture that is of considerable importance in certain localities is the production of young bunching onions for the early spring trade. In several sections along the South Atlantic coast the growing of this class of onions is quite an enterprise. Many persons who are engaged in other lines of work follow the practice of growing a small area of bunching onions as a side issue.

The varieties known as multipliers and top onions are generally employed for this purpose; however, bunching onions are sometimes grown from ordinary sets, from inferior and damaged large onions, and from seed.

CULTURAL METHODS

For growing bunching onions the bulbs or sets are planted during the autumn either in beds or in rows 12 or 14 inches apart with the bulbs quite close in the rows. The bulbs will start growing within a short time and make more or less growth during the winter. As soon as the weather becomes warm during the first months of spring the onions make a rapid growth and are ready for marketing about the time peach trees begin to bloom.

The land upon which these onions are grown should be rich and mellow, but very little actual cultivation will be required. Where the winters are severe it may be necessary to provide slight protection, either a little straw, loose manure, leaves, pine straw, or corn fodder that has been run through a shredder. If the onion beds are protected on the windward sides by means of a windbreak consisting of a grove of pine trees, a fence of boards, pine boughs, or corn fodder, the crop will be ready for marketing a little earlier than if left exposed. Multiplier onions not gathered for marketing are allowed to remain to form the bulbs for planting the following season.

MARKETING

In marketing this class of onions the young scallions are pulled, the roots trimmed, and the outside peeled off, leaving the stem white and clean. They are then tied in small bunches by means of soft white string, the tops trimmed slightly, and the bunches packed in crates or baskets for shipment or for sale on the local market. This phase of the onion industry is limited to small plantings and is well suited to the general market garden.

During the spring and early summer large quantities of ordinary young onions are pulled when the bulb is about the size of a 50-cent piece, the roots and tops are trimmed, and they are then bunched and sold for stewing purposes. So far as known, this class of onions is not shipped to any great extent, but is sold mainly on local markets.

DISEASES OF THE ONION

The onion crop of the United States is by no means free from disease. For information regarding such diseases and measures of control, the reader is referred to Farmers' Bulletin 1060, Onion Diseases and Their Control, published by the United States Department of Agriculture, Washington, D. C.

ONION INSECTS AND THEIR CONTROL

In the United States the onion crop has only two serious insect pests. Of these, the onion thrips (*Thrips tabaci* Lind), because of its distribution over the entire country, is probably the most injurious. It is nearly always present on onions, and under favorable conditions it may increase to such an extent as to become very destructive. The onion thrips is a very small louselike insect, pale brown in color, and usually is first noticed because of the minute whitish spots which it leaves on the tips of the foliage after rasping away part of the leaf surface in feeding. The eggs are laid just beneath the surface of the leaf, and the insects, in both the mature and immature forms, feed on the surface from the sheath to the tip. In serious infestations the tops of the onions become grayish white, afterwards turning brown and dying. At such times the leaves, if examined, may be seen to be covered with thrips.

The onion thrips is particularly injurious in the South, and in the Texas Bermuda-onion district it is a constant menace to the crop. It is particularly likely to injure plantings which follow or are adjacent to such early crops as cabbage, from which the thrips migrate in great numbers at harvest time. A vigorous, strongly growing onion crop may grow away from thrips injury, but if for any reason growth becomes badly checked, damage is almost sure to result.

Recent experiments[3] have shown that the thrips can be controlled and the yield materially increased by the use of naphthalene dust. Crude naphthalene is crushed with a heavy roller on a cement floor and sifted through a 50-mesh screen. Forty pounds of the naphthalene is mixed with 60 pounds of hydrated lime. To be most effective the dust should be allowed to stand in a tight container for at least 24 hours.

The dust is applied at the rate of 200 pounds to the acre. The first application should be made when the injury first becomes apparent and repeated at intervals of about a week. The dust is applied with a rotary hand duster or with a power duster attached to a garden tractor. The dust is directed into the crown of the plants. The applications should be made in the morning while the air is still and the plants are wet with dew. From 3 to 5 applications, depending on the severity of the infestation, are required.

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[3] Cornell University Extension Bulletin 206, Diseases and Insects Affecting Vegetable Crops.

Thrips may be fairly well controlled by spraying with nicotine at the rate of three-fourths of a pint of a 40-percent solution to 50 gallons of water in which 4 pounds of soap has been dissolved. Use a high-pressure sprayer and hold the nozzle close to the plants, as thrips often feed and remain protected in the leaf sheaths and creases. Clean up weed patches near the onion fields and rake together and burn the onion tops as soon as the crop is harvested. The grower should examine his onion plantings from time to time in order to detect the early stages of the infestation. It is easier to keep an infestation down by early treatments than to control a heavy infestation.

In the northern part of the United States the onion maggot (*Hylemyia antiqua* Meig.) often becomes very destructive, especially to small seedling onions. This pest is a white, footless maggot, the larva or young of a fly much resembling the common house fly, and is about three-eighths of an inch in length when full grown. The eggs are laid by the fly early in the spring, and are placed, in the case of seedling onions, on the ground near the plant, or in the sheaths of the leaves near the ground. On hatching, the young maggot burrows into the plant and bores through the stem and bulb, easily killing small seedlings. After killing one plant it proceeds to the next, thus causing many skips in the row. When larger plants are attacked, several larvae may be found in the bulb.

A remedy that has been used successfully in some sections consists of treating the soil about the plants with a bordeaux-oil emulsion. The emulsion is best applied to the onion rows by means of a sprayer, the material being directed to the base of the plants. Enough of the material should be applied to moisten the soil at the base of the plants. The bordeaux-oil emulsion may be prepared by adding 1½ gallons of oil emulsion, suitable for use against orchard scale insects, to 48½ gallons of 4–4–50 bordeaux mixture. Apply five times at weekly intervals, beginning when the young plants are about an inch high. An effective treatment requires about 115 gallons of the spray per acre.

Cutworms are sometimes troublesome, but are easily controlled by the bran mash and arsenic bait, scattered thinly wherever the young seedlings have been found to be cut off.[3]

PRESENT STATUS OF THE ONION INDUSTRY

Because of variations in the cost of labor, tools, fertilizers, seed, and other materials and the many factors involved in the production of an onion crop it is impossible to give definite cost and profit figures. The average yield of onions is around 290 bushels to the acre, but yields of 400 to 600 bushels are not uncommon. The price of onions is extremely variable one year with another, but on the whole the crop has proved profitable to the growers when taken on an average for a period of years.

In some sections onions are grown in rows 3 feet apart and given horse cultivation, thus reducing the yield to about 150 bushels on an acre and cutting down production costs in proportion. This method of growing onions is especially adapted for use on low-priced land and where hand labor is scarce.

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[3] For further information write to the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

Both the supply and demand for onions are increasing and at present bear about an equal relation to each other. Some years the supply falls a little short and the prices go somewhat higher, with the result that larger quantities are imported. The following season the plantings are generally heavier, the market may be a little slow, and the result will be low prices and a great many people will discontinue the growing of onions or reduce their acreage.

Prices of onions, especially the Texas-grown Bermuda onions, are greatly influenced by importations of Egyptian onions which appear on our markets about the same time of the year that the Bermuda onions are being marketed. The ease with which both the Egyptian and the Spanish onions can be delivered to our eastern markets as compared with the long freight haul from southwestern Texas or Pacific Coast States renders the position of the American grower of Bermuda and other mild onions more or less hazardous. Despite this condition, however, both the Bermuda and the Spanish onion industries have become well established in the United States. The American grower of Bermuda onions is still dependent upon the Canary Islands for his seed supply.

Recently the production of the large Sweet Spanish or Valencia type onion has become well established in a number of the Western States, and with the present tariff rate in effect on imported Spanish and other onions American growers are in position, under normal crop conditions, to fully supply the principal markets of the United States. American growers of the Sweet Spanish or Valencia type onions are no longer dependent upon imported seed, as an adequate supply is now being produced by the California and other western seed growers.

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No

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 354

ONION CULTURE

THE ONION, in one or more of its several forms, has been in use throughout all time of which we have authentic history. It is of Old World origin, but was brought to North America by the early discoverers and colonists. The onion is grown universally in home gardens and is one of our important market-garden and truck crops. It is adapted for growing on a wide range of soil types and under varying climatic conditions, but requires a rich soil and plenty of moisture.

Onions are an intensive crop, their production involving considerable hand labor, but yielding a relatively high return per acre. Prices received by the growers vary considerably from one year to another, but the production of onions in the United States is fairly well stabilized and adjusted to market demands.

Recently there has been developed in several of the Western States a specialized industry in the production of the Valencia onion. The Bermuda-onion industry of southern Texas and California has been expanded and extended to several other sections.

The production and shipment of large numbers of early seedling onion plants by southern plant growers has to a certain degree replaced the use of onion sets for planting in home gardens and for a portion of the northern early market crop.

Washington, D. C.

Issued April 26, 1909
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ONION CULTURE

By W. R. Beattie, *senior horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

CONTENTS

Page
- Introduction 1
- Climatic requirements 2
- Soils adapted to onion culture 3
- Cultural methods 4
  - Preparation of new land 4
  - Crop rotation 4
  - Preparation of the soil 5
  - Fertilizers 6
  - Planting 8
  - Cultivation 11
  - Irrigation 13
- Harvesting and curing 14
- Storage 17
- Marketing 20
- Commercial varieties 21
- Production of Bermuda onions 22
  - Soils and climate adapted to the Bermuda onion 22
  - Cultural methods 23
  - Harvesting and marketing 23
  - Yield of Bermuda onions and prices obtained 23
- Green onions for bunching 24
  - Cultural methods 24
  - Marketing 24
- Garlic and leeks 25
- Diseases of the onion 25
- Onion insects and their control 25
- Present status of the onion industry 27

INTRODUCTION

THE ONION is one of the important market-garden and truck crops in the United States and is very generally grown in home gardens. It thrives best on alluvial and drained muck soils under a temperate climate, but may be grown under a very wide range of soil and climatic conditions. Onions are grown to perfection on the alluvial soils of the Nile River Valley in Egypt, under the sea breezes of the South Sea Islands, on the delta lands along the seacoast, on sandy uplands, in the arid regions under irrigation, and on reclaimed swamp lands. There is perhaps no extensive area in the United States or its possessions where the onion, in one or more of its forms, can not be successfully grown, at least for home and local use.

The onion is of Old World origin and has been used as a food plant from the earliest historic times. It was an important article of diet in Egypt at the time of the building of the pyramids, and Moses, in his account of the exodus of the Children of Israel from Egypt, mentions it as one of the articles of food for which the Israelites longed during their sojourn in the wilderness.

Onions were brought to North America by the early discoverers and became one of the common crops of colonial gardens. Commercial onion culture in its present form has developed mainly during the last 40 or 50 years. Formerly the production of onions for sale was confined principally to the New England States, but the industry soon spread to other sections, and when the vast muck areas of the Great Lakes and other regions were drained and brought under cultivation the onion soon became one of the most important crops on these soils.

duced on light or sandy soils than on muck or clay loams. Those of the Bermuda, Spanish, and Egyptian types flourish on the deep, rich alluvial soils of the river bottoms and delta regions.

Certain of our markets show a decided preference for onions belonging to a particular type. The red and brown varieties find ready sale on the markets of the Middle West, while onions of the yellow and white varieties are preferred in the eastern cities. Onions will withstand long-distance shipment, those of the mild type being generally more subject to injury than the strong sorts. Some of the white varieties also have a thin skin and are easily injured. It should be the aim of every grower to employ varieties that will withstand handling and at the same time find ready sale on the market.

The top or tree onion, which reproduces by means of small bulblets formed on the top of the seed stalk, is extensively used in the production of early-spring bunching onions.

The multiplier or potato onion reproduces by a division of the bulbs. In growing this variety it is necessary to plant large bulbs to produce sets for the next year's planting and small bulbs or sets for the crop of large onions. The bulbs of this variety may remain in the soil year after year and are desirable for use early in spring.

Garlic is closely allied to the onion, but will remain in the ground from one year to another in a mild climate if undisturbed. Garlic is planted by setting the small bulbs, or cloves, in either the autumn or early spring. The culture is practically the same as for the onion.

The leek also belongs to the same class as does the onion, but requires somewhat different treatment. The seed is usually sown in beds and the plants transplanted about 4 inches apart in the row. The plants of the leek are given about the same cultivation as onions, except that after they have attained almost full size the soil is drawn around them to a height of 6 or 8 inches to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored in cellars for winter use.

PRODUCTION OF BERMUDA ONIONS

Bermuda onions are now an important commercial crop in Texas and California, with small plantings in a number of the Southern States. The Bermuda onion fields of Texas are located around Laredo and other points in or near the Rio Grande Valley.

SOILS AND CLIMATE ADAPTED TO THE BERMUDA ONION

Soils of a silty or alluvial nature are suited to the production of Bermuda onions, and those containing considerable sand are most desirable. As already noted in referring to fertilizers for onions, the Bermuda requires a very rich soil for the best results, and this can only be obtained by first selecting a good soil and then manuring heavily. The Bermuda onion as grown in this country is a winter crop; therefore, mild climatic conditions are required. While the plants would withstand considerable freezing, their growth is seriously checked by cold weather, and the crop will not mature in time for the early market if grown to the northward.

CULTURAL METHODS

The cultural methods employed in the growing of Bermuda onions are essentially the same as those for ordinary onions. As the greater portion of the crop is grown in a region which has no regular rainfall, irrigation methods are employed almost universally. The greater part of the crop is grown by the transplanting process and a great amount of hand labor is required. The seeds are sown in specially prepared outdoor beds from the middle of September to the middle of October, and the seedlings are transplanted to the field November 20 to January 10, or even later. From 3½ to 4½ pounds of seed are required for each acre to be planted; this will allow for discarding all the weaker plants. The plants are allowed to remain in the seed bed until they are from three-sixteenths to one-fourth inch in diameter before they are transplanted. As the seedlings are lifted the greater portion of both the small roots and the tops is trimmed off in order that they may be transplanted more readily. (Fig. 4.)

HARVESTING AND MARKETING

Bermuda onions are harvested as early as possible, generally before the tops have become fully ripened. For removing the bulbs from the ground a 1-horse plow, a potato digger, or a cultivator with a cutter wing attached is employed. The bulbs are then separated from the soil by hand, the tops cut off with shears, and the onions thrown in windrows or piles to dry in practically the same manner as for the regular-crop onions in the North. After the bulbs have become thoroughly dry on the surface they are either placed directly in the crates for shipment or are carried to a packing shed to be graded and packed for market.

During the early days of the Bermuda-onion industry the crop was shipped largely in bags, but it was soon found that the bulbs were too perishable for this method of handling. At present the greater portion of the crop is sent to market in folding slat crates that are about 20 inches long, 12 inches wide, and 12 inches high.

These crates hold approximately 50 pounds of onions and weigh 56 or 57 pounds when filled. The cost of these crates is about $20 a hundred, but they add enough to the attractiveness and carrying qualities of the onions to make their use profitable.

YIELD OF BERMUDA ONIONS AND PRICES OBTAINED

Phenomenal yields of 34,000 and 35,000 pounds of Bermuda onions are frequently made on an acre of land, but this is far above the general average, which is in the neighborhood of 10,000 or 12,000 pounds to the acre. Many fields, especially when planted for the first time, do not yield as much as 10,000 pounds to the acre. On land that has been heavily manured and planted to onions for several years the yield averages about 16,000 pounds.

The best Bermuda-onion farms are valued at $300 to $500 an acre. In order to prove profitable, the growing of Bermuda onions should be conducted on a comparatively large scale. The necessary land and irrigation facilities will require the initial outlay of from $10,000 to $30,000, and the running expenses are quite heavy. Labor can be

this may often be applied by means of crops of legumes grown upon the land and plowed under.

Throughout the north-central part of the United States there are vast tracts of peat or muck soils that are capable of producing onions. Before planting to onions, however, these soils must be cleared, drained, and brought to a suitable state of cultivation. In many cases this process will require two or three years' time, but sometimes the soil can be broken during the early winter, allowed to lie exposed to the action of frost, then worked down and planted to onions the following spring. Some of the largest onion farms are located on muck lands. The store of plant food in muck soil is usually large, but often it is not in available condition, and heavy applications of manure and commercial fertilizers, especially superphosphate and potash, are essential to profitable crops.

CULTURAL METHODS

The onion belongs to that class of crops which gives best results under very intensive culture, and the greatest yields are secured where a moderate acreage is planted and the work conducted in a most thorough manner. There is nothing technical about the growing of onions, but close attention and frequent cultivation are essential. Once the weeds get a start, the cost of production will be greatly increased, or the crop may be lost altogether.

PREPARATION OF NEW LAND

As a general rule new land is not adapted to onion growing until it has been worked one or two years with other crops. Onions should follow some row crop that has been kept free from weeds the previous season. Corn, beans, and potatoes are suitable crops with which to precede onions. Muck and sandy soils may in some cases be brought to a suitable condition for onions the first season, but the fitting will have to be very thoroughly performed. The land should be plowed in the autumn, then replowed in the spring, after which numerous harrowings and doubtless some hand work will be required to get the soil in suitable shape.

If necessary to manure the land heavily before planting to onions, it will be desirable to plant to some farm crop one season, then apply the manure during the autumn in order to give it time to become incorporated with the soil. Owing to the value of good onion land it would not be advisable to devote it to general farm crops for any extended period, although corn is frequently planted and oats or rye are sometimes used in the North. Cowpeas may be of great service in bringing new land into shape for planting to onions.

CROP ROTATION

Onions should not be planted on the same piece of land year after year, but some system of crop rotation should be maintained. Care should be taken, however, to use crops in the rotation that will not be exhaustive of the high fertility necessary in the onion land. During the years when the land is not devoted to onions it can be planted to some truck crop that will give a return that will justify the appli-

cation of large quantities of fertilizers, or, better, to a leguminous crop to be turned under as green manure. Continuous cropping with onions will cause the land to become infested with both disease and insect enemies that will sooner or later injure the crop to such an extent as to render it unprofitable.

PREPARATION OF THE SOIL

Assuming that the land intended for planting to onions is capable of being brought to a good mechanical condition, is fertile, well drained, and reasonably free from weed seeds, the first step in the production of the crop will be to plow moderately deep, then harrow, disk, roll, and drag until the soil is smooth and mellow to a depth of 5 to 7 inches. The method of preparing the soil will depend somewhat upon its character, the manner of planting to be followed, and the requirements for irrigation. There are few truck or other crops that require so careful fitting of the soil as do onions, and it is essential that the fertilizers be well mixed with the soil.

On soils that are naturally well drained and where surface water can not accumulate, the plowing may be done in large blocks, but where the opposite conditions are found or irrigation is practiced it may be necessary to plow the land in narrow beds. In the case of insufficient drainage it will be desirable to throw the soil into beds, leaving double furrows between the beds to carry off surplus water. Where the flooding system of irrigation is practiced the beds must be leveled and a system of ditches and ridges provided for distributing and controlling the water. Where it is merely desired to secure surface drainage the beds may be from 75 to 150 feet in width, but for irrigation purposes the beds are generally but 12 or 15 feet in width. If spring plowing is practiced the soil should be harrowed closely behind the plow in order to prevent drying out.

For cutting and pulverizing the soil there is perhaps no tool as serviceable as the disk harrow. There is a type of disk having four gangs, in two sets, one combination in front of the other and so arranged that the soil is first turned to the center and then turned outward again by means of the rear combination. This tool turns the soil twice and leaves it in a level condition. For smoothing and leveling the soil behind the plow a harrow of the type shown in Figure 1 is very desirable; this tool not only levels but turns and crushes the soil at the same time.

On land that has been plowed during the autumn and requires replowing in the spring, a device of the type shown in Figure 2 will answer and will do the work more rapidly than the plow. This tool is especially adapted to bedding up land that has been previously plowed.

For imparting the final smoothing touch to the soil before planting there is a device consisting of a large number of small disks set in a wooden frame (fig. 3) which does about the same work as a steel rake, but in a rapid manner. A drag or float made from several pieces of scantling nailed together may be used for this purpose, or if the soil is very loose a roller should be run over it. The final leveling should be performed with a tool that will fill and obliterate all tracks or other depressions in the soil, leaving a smooth, even seed bed for either seed sowing or transplanting.

Thrips may be fairly well controlled by spraying with nicotine at the rate of three-fourths of a pint of a 40-percent solution to 50 gallons of water in which 4 pounds of soap has been dissolved. Use a high-pressure sprayer and hold the nozzle close to the plants, as thrips often feed and remain protected in the leaf sheaths and creases. Clean up weed patches near the onion fields and rake together and burn the onion tops as soon as the crop is harvested. The grower should examine his onion plantings from time to time in order to detect the early stages of the infestation. It is easier to keep an infestation down by early treatments than to control a heavy infestation.

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- Present status of the onion industry 27

INTRODUCTION

THE ONION is one of the important market-garden and truck crops in the United States and is very generally grown in home gardens. It thrives best on alluvial and drained muck soils under a temperate climate, but may be grown under a very wide range of soil and climatic conditions. Onions are grown to perfection on the alluvial soils of the Nile River Valley in Egypt, under the sea breezes of the South Sea Islands, on the delta lands along the seacoast, on sandy uplands, in the arid regions under irrigation, and on reclaimed swamp lands. There is perhaps no extensive area in the United States or its possessions where the onion, in one or more of its forms, can not be successfully grown, at least for home and local use.

The onion is of Old World origin and has been used as a food plant from the earliest historic times. It was an important article of diet in Egypt at the time of the building of the pyramids, and Moses, in his account of the exodus of the Children of Israel from Egypt, mentions it as one of the articles of food for which the Israelites longed during their sojourn in the wilderness.

Onions were brought to North America by the early discoverers and became one of the common crops of colonial gardens. Commercial onion culture in its present form has developed mainly during the last 40 or 50 years. Formerly the production of onions for sale was confined principally to the New England States, but the industry soon spread to other sections, and when the vast muck areas of the Great Lakes and other regions were drained and brought under cultivation the onion soon became one of the most important crops on these soils.

At present the principal commercial onion-growing centers are located in New England, especially in the Connecticut River Valley, in northern New Jersey, southeastern New York, the entire Great Lakes region, and as far west as Minnesota. The production of Creole onions centers around New Orleans, La., and the greater part of the Bermuda-onion crop is grown in southwestern Texas and in California. Within the last few years the production of the mild Valencia onion has developed in several of the Western States, including New Mexico, California, Arizona, Utah, Nevada, Washington, and Oregon. In addition there are many local areas in the United States where onions are being grown in considerable quantities for the market.

The production of several crops closely related to the onion, such as chives, shallot, leek, and garlic, has been developed around local centers, especially in connection with market gardening near the large cities. Garlic might be mentioned as an exception, because it is produced mainly in a few localities where soil and climate are especially suitable for its growth.

The present acreage and production of onions in the United States are about equal to market demands. During years of short crops and low yields there is a shortage of onions with consequent high prices, but during years of heavy crops the supply, as a rule, exceeds the demand, and frequently prices are too low for profitable returns to the grower.

CLIMATIC REQUIREMENTS

For best results a temperate climate without great extremes of heat and cold should be selected. Onion culture is rarely profitable in regions where the climate does not change or has no definite seasons of heat and cold or moisture and drought. The onion does best under rather cool conditions, with plenty of moisture during its early stages, but requires a reasonable degree of heat, together with dryness of both soil and atmosphere, for its proper ripening. Where the onion industry has become established in the extreme southern part of the United States, the growing season is during the late autumn and winter, the crop maturing during the spring and early summer. If the crop matures at a time when there is considerable rainfall, it will be impossible to cure the bulbs without artificial means and they will be lacking in keeping qualities.

Certain types and varieties of onions, including the top onions and the multipliers or potato onions, are extremely hardy and may remain in the open ground throughout the winters of our Northern States, especially if given slight protection. These types are, however, not adapted to growing for market, except as green onions, "peelers," or "bunchers," to be sold during the early springtime. In certain sections of the South Atlantic coast region large areas of the top and multiplier onions are grown for this purpose. There is also a marked difference in the day-length requirements of the standard commercial sorts, some being adapted to growing far northward, while others, like the Bermuda, Egyptian, and Spanish types, do best in restricted southern localities.

The period required for the production of a crop of onions will depend upon the season, the methods employed in growing, and the

variety. If grown from seed, a period of from 130 to 150 days will be required. If from sets, the crop often may be matured in 100 days. If grown in the extreme northern part of the United States, where the seasons are short, the crop will mature more rapidly than to the southward. In the case of the Bermuda onion, as grown in Texas, the growing season extends from October to the following March or April.

Onions require an abundance of moisture during the early stages of their growth, but should be ripened under comparatively dry conditions. In most sections the seed is sown at a time of the year when frequent spring rains occur. Their period of greatest growth is during the early part of the summer, and the crop is ripened late in the summer when drying conditions may be expected. In irrigated regions the application of water is almost entirely under the control of the grower. During the active period of growth the water is applied about once a week, the soil being thoroughly soaked and the surplus water drawn off.

The amount of rainfall or irrigation required for the production of a crop of onions will depend largely upon the character of the soil and its drainage. Many of the peat or muck soils in which the soil water remains near the surface will require very little rainfall; in fact, the best crops of onions are produced on these soils during seasons of comparatively light but evenly distributed rainfall. Sandy and loose soils generally will require a greater amount of water, especially during the early part of the season.

SOILS ADAPTED TO ONION CULTURE

The essential requirements of a soil upon which to grow onions profitably are a high state of fertility, good mechanical condition in order that the crop may be easily worked, sufficient drainage, and freedom from weeds. If a soil has the proper mechanical properties—that is, if it contains sufficient sand and humus to be easily worked, is retentive of moisture and fertilizers, and is capable of drainage—all other requirements can be met. At least three types of soil are being extensively planted to onions in this country, the one common essential being proper mechanical condition.

Clay and alluvial loam soils abound in the river valley and delta regions near the coast. These soils are generally very fertile, but may require the addition of humus or stable manure in order to lighten them. The greatest difficulty encountered in growing onions upon land of this character is the tendency of the soil to run together and bake after hard rains. This is especially injurious after the seed has been sown and before the small plants have attained sufficient size to permit of stirring the soil about them. Where these soils contain considerable sand they are ideal for onion culture. It is upon this class of soil that the greater part of the Bermuda, Spanish, and Egyptian onions are grown.

Sandy soils, especially where underlain by a well-drained clay subsoil, are often well adapted to onions. Soils of this character generally require heavy applications of fertilizers before they will produce a paying crop, but the quality of the product is excellent. Onions grown on sandy loams are generally solid, heavy, and of excellent keeping quality. Where sandy soils are lacking in humus

this may often be applied by means of crops of legumes grown upon the land and plowed under.

Throughout the north-central part of the United States there are vast tracts of peat or muck soils that are capable of producing onions. Before planting to onions, however, these soils must be cleared, drained, and brought to a suitable state of cultivation. In many cases this process will require two or three years' time, but sometimes the soil can be broken during the early winter, allowed to lie exposed to the action of frost, then worked down and planted to onions the following spring. Some of the largest onion farms are located on muck lands. The store of plant food in muck soil is usually large, but often it is not in available condition, and heavy applications of manure and commercial fertilizers, especially superphosphate and potash, are essential to profitable crops.

CULTURAL METHODS

The onion belongs to that class of crops which gives best results under very intensive culture, and the greatest yields are secured where a moderate acreage is planted and the work conducted in a most thorough manner. There is nothing technical about the growing of onions, but close attention and frequent cultivation are essential. Once the weeds get a start, the cost of production will be greatly increased, or the crop may be lost altogether.

PREPARATION OF NEW LAND

As a general rule new land is not adapted to onion growing until it has been worked one or two years with other crops. Onions should follow some row crop that has been kept free from weeds the previous season. Corn, beans, and potatoes are suitable crops with which to precede onions. Muck and sandy soils may in some cases be brought to a suitable condition for onions the first season, but the fitting will have to be very thoroughly performed. The land should be plowed in the autumn, then replowed in the spring, after which numerous harrowings and doubtless some hand work will be required to get the soil in suitable shape.

If necessary to manure the land heavily before planting to onions, it will be desirable to plant to some farm crop one season, then apply the manure during the autumn in order to give it time to become incorporated with the soil. Owing to the value of good onion land it would not be advisable to devote it to general farm crops for any extended period, although corn is frequently planted and oats or rye are sometimes used in the North. Cowpeas may be of great service in bringing new land into shape for planting to onions.

CROP ROTATION

Onions should not be planted on the same piece of land year after year, but some system of crop rotation should be maintained. Care should be taken, however, to use crops in the rotation that will not be exhaustive of the high fertility necessary in the onion land. During the years when the land is not devoted to onions it can be planted to some truck crop that will give a return that will justify the appli-

cation of large quantities of fertilizers, or, better, to a leguminous crop to be turned under as green manure. Continuous cropping with onions will cause the land to become infested with both disease and insect enemies that will sooner or later injure the crop to such an extent as to render it unprofitable.

PREPARATION OF THE SOIL

Assuming that the land intended for planting to onions is capable of being brought to a good mechanical condition, is fertile, well drained, and reasonably free from weed seeds, the first step in the production of the crop will be to plow moderately deep, then harrow, disk, roll, and drag until the soil is smooth and mellow to a depth of 5 to 7 inches. The method of preparing the soil will depend somewhat upon its character, the manner of planting to be followed, and the requirements for irrigation. There are few truck or other crops that require so careful fitting of the soil as do onions, and it is essential that the fertilizers be well mixed with the soil.

On soils that are naturally well drained and where surface water can not accumulate, the plowing may be done in large blocks, but where the opposite conditions are found or irrigation is practiced it may be necessary to plow the land in narrow beds. In the case of insufficient drainage it will be desirable to throw the soil into beds, leaving double furrows between the beds to carry off surplus water. Where the flooding system of irrigation is practiced the beds must be leveled and a system of ditches and ridges provided for distributing and controlling the water. Where it is merely desired to secure surface drainage the beds may be from 75 to 150 feet in width, but for irrigation purposes the beds are generally but 12 or 15 feet in width. If spring plowing is practiced the soil should be harrowed closely behind the plow in order to prevent drying out.

For cutting and pulverizing the soil there is perhaps no tool as serviceable as the disk harrow. There is a type of disk having four gangs, in two sets, one combination in front of the other and so arranged that the soil is first turned to the center and then turned outward again by means of the rear combination. This tool turns the soil twice and leaves it in a level condition. For smoothing and leveling the soil behind the plow a harrow of the type shown in Figure 1 is very desirable; this tool not only levels but turns and crushes the soil at the same time.

On land that has been plowed during the autumn and requires replowing in the spring, a device of the type shown in Figure 2 will answer and will do the work more rapidly than the plow. This tool is especially adapted to bedding up land that has been previously plowed.

For imparting the final smoothing touch to the soil before planting there is a device consisting of a large number of small disks set in a wooden frame (fig. 3) which does about the same work as a steel rake, but in a rapid manner. A drag or float made from several pieces of scantling nailed together may be used for this purpose, or if the soil is very loose a roller should be run over it. The final leveling should be performed with a tool that will fill and obliterate all tracks or other depressions in the soil, leaving a smooth, even seed bed for either seed sowing or transplanting.

FERTILIZERS

As the onion is an intensive crop and should yield great quantities of marketable bulbs for the area planted, the grower is justified in fertilizing heavily. It would be difficult indeed to make the soil too rich for onions, provided the manures are thoroughly incorporated with the soil. A heavy application of fresh raw manure just before planting would have an injurious effect, but where the manure is well rotted and uniformly applied there is nothing to be feared.

ANIMAL MANURES

There is perhaps no fertilizer so well adapted to the production of onions as plenty of disease-free, well-composted stable manure, and the quantity and frequency of application will depend upon the nature of the land under cultivation. The Bermuda-onion growers of southwestern Texas apply as high as 20 tons of sheep and goat manure to an acre every three years. In addition to the manure there is used 1,000 to 2,000 pounds of cottonseed meal or commercial fertilizer, and sometimes a top-dressing of nitrate of soda. This sheep and goat manure, from animals that are fed largely on cottonseed meal, is saved in the corrals in a climate where there is very little rain, and contains the essential fertilizing ingredients in very high percentages. The manure is first piled where a little water can be thrown over it and it is composted for several months before spreading on the land. The best results from this manure are not realized until the second or even the third year after its application.

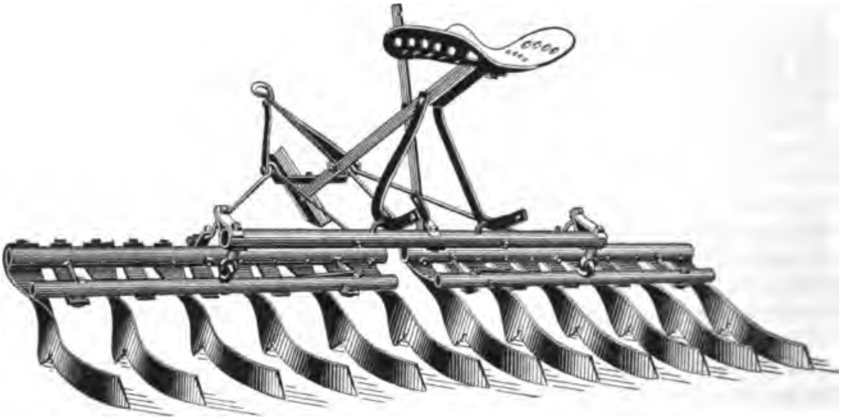

FIGURE 1.—Harrow for smoothing and leveling the soil behind the plow

All stable manure used on onion land should be well composted before use and then spread upon the land several months before planting to onions. In the Northern States the manure may be applied during the autumn and well disked into the soil. The land can then be allowed to lie in the rough state and exposed to the action of frost during the winter, or it can be smoothed and seeded to rye, in which case it will be necessary to replow early in spring. In the Bermuda district the manure should be applied during the

spring and the land kept frequently stirred during the summer, with occasional irrigations in order to incorporate the manure and destroy weeds; the planting is not done until the autumn. Another practice in the Bermuda district is to apply fresh manure broadcast at the rate of 10 to 12 tons to the acre during the spring, then plant to corn and cultivate through the early summer, and add a top-dressing of well-rotted manure after plowing the land for onions in the autumn. This top-dressing should be well worked into the soil by means of disk harrows. Large quantities of fresh manure applied on onion land just before planting will have a tendency to produce an overgrowth of tops at the expense of the bulbs. This is especially true on irrigated lands and soils that are naturally moist.

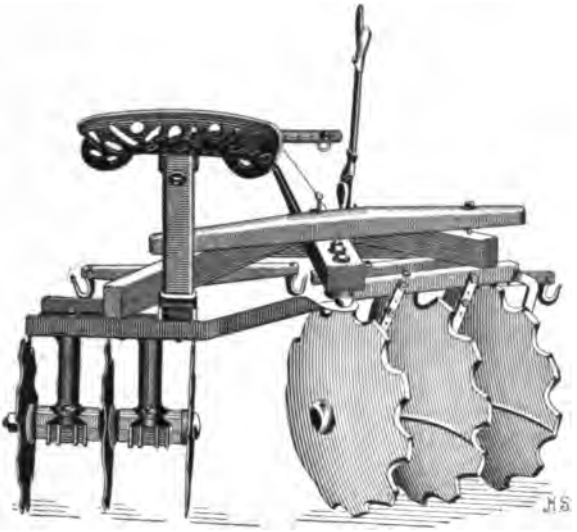

FIGURE 2.—Disk plow used for refitting land

COMMERCIAL FERTILIZERS

A fertilizer that is suited to the growing of potatoes will serve quite well for onions, but the potash should perhaps be supplied in the form of muriate rather than of sulphate. A fertilizer adapted to the growing of onions should contain 4 to 5 per cent of nitrogen, 8 to 10 per cent of phosphoric acid, and 8 to 10 per cent of potash.

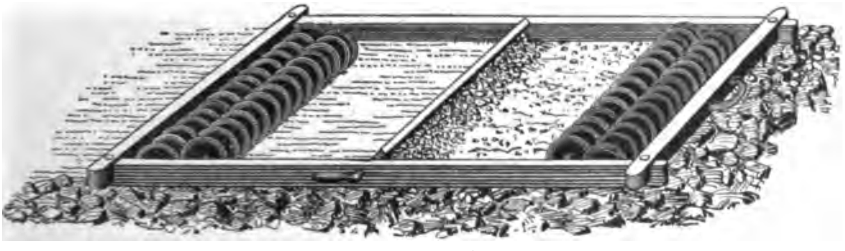

FIGURE 3.—Device used for smoothing soil before seeding

A fertilizer of this character can be profitably applied at the rate of 1,000 pounds to the acre on most soils. Where very intensive cultivation is practiced it may be profitable to apply as much as a ton to the acre in addition to stable manure.

Commercial fertilizers should be applied shortly before sowing the seed and should be uniformly distributed and thoroughly worked into the soil. There are fertilizer distributors that scatter the fertilizer broadcast, but where an amount not exceeding 1,000 pounds of fertilizer to the acre is being used the work of distribution may be performed by means of a common grain drill having a fertilizer attachment. On a small scale the work is generally performed by hand.

Many growers follow the practice of applying only a part of the fertilizer at planting time, reserving the balance to be put on as a top-dressing at some time during the period of cultivation. This plan is especially desirable where onions are grown during the winter, as the application of highly nitrogenous fertilizers in the autumn is liable to promote a soft growth that will be injured by cold. If the fertilizer is not put on until cold weather is over, the crop may be forced without danger of injury. For this purpose only those fertilizers of a very available form will answer. Nitrate of soda is frequently used as a top-dressing during the height of the growing period.

PLANTING

Most of the onions grown in the United States are started from seed. Propagation from seed is conducted by three more or less distinct methods: (1) By sowing the seed in the rows where the crop is to grow and mature; (2) by sowing the seed in specially prepared beds and transplanting the seedlings to the open ground; and (3) by first growing sets from seed and then, after keeping them through the winter, planting them in the field to produce the crop of mature bulbs. Of these three methods the one first mentioned of seeding in the rows where the crop is to mature is the one most used on a very large scale.

SEEDING IN ROWS

In the northern onion-growing districts the seed is sown as early in the spring as the soil can be brought to the proper condition. While it is desirable to plant quite early, it never pays to sow the seed before the land is in the best possible condition. When the soil has been brought to a smooth, even surface and is fine and mellow, the seed is sown by means of a common seed drill, of which there are several makes on the market. The hand drills which sow one row at a time are extensively employed, but many of the larger growers employ a gang of drills hitched together and plant from five to seven rows at once. In heavy or moist soils the depth to cover the seed should not be more than one-half to three-fourths inch, while on loose and sandy soils the seed may be covered about an inch.

Where hand cultivation is practiced throughout, the usual distance between rows is 12 to 16 inches. Where horse culture is employed the distance between rows varies between 24 and 36 inches. The quantity of seed required to plant an acre will depend both upon the distance between rows and the purpose for which the onions are being grown. For the growing of standard market onions in rows 14 inches apart, about 4½ pounds of first-class seed will be required. With the rows 3 feet apart, but 1¼ to 1½ pounds will be necessary. Where it is

desired to produce small onions for pickling purposes, the amount of seed may be as great as 25 pounds to an acre. Good seed is essential, and if there is any doubt regarding the vitality of the seed it should be tested before planting by counting and planting 400 or 500 seeds in a window box and then determining the germination by counting the seedlings after 10 days' or 2 weeks' time. First-class seed is seldom sold at a low price and good seed at $1.50 or even $2.50 a pound may be cheaper in the end than poor seed at 50 cents. Old and inferior seeds are not only low in percentage of germination, but lack the vitality necessary to produce strong, healthy plants. There are dealers who make a specialty of securing and furnishing extra-quality onion seed, and while their prices are often somewhat above the general market the seed furnished by them is preferable to ordinary seed.

Experienced growers are able by using extreme care in regulating the drills to distribute onion seed in rows where the crop is to mature so that little thinning will be necessary. Thinning is generally left until the time of the first hand weeding, when all thick bunches along the rows are thinned to a uniform stand of 8 or 10 plants to the foot. It is always well, however, to allow for considerable loss of plants, and unless the plants are so thick as to actually crowd, thinning will not be necessary.

TRANSPLANTING METHOD OF GROWING ONIONS

The transplanting process is merely a modification of the regular seeding method. The objects gained by transplanting are an earlier crop, a uniform stand, and bulbs of more regular size. Practically the entire crop of Bermuda-type onions grown in the United States is handled in this manner. Where a small area is to be grown, the transplanting process is the ideal method, but for large acreages where labor is difficult to obtain this would not be practical. After transplanting, the seedlings will require rain or watering, and for this reason the transplanting process is practically limited to areas where some form of irrigation is available.

In growing onions by the transplanting method the seed is sown in greenhouses, hotbeds, coldframes, or specially prepared beds at the rate of 3½ or 4 pounds for each acre to be planted. Onion seedlings are now being grown in great quantities by southern plant growers and are shipped to northern onion growers. When the seedlings are grown under cover, they are given the necessary attention regarding watering and ventilation and kept growing quite rapidly until near the time for setting them in the open ground. As planting time approaches, the seedlings are "hardened" or prepared for transplanting by increased ventilation and exposure and by withholding water. When ready to transplant, the seedlings should be somewhat smaller than a lead pencil and rather stocky. The plants are lifted from the seed bed and the roots and tops both trimmed somewhat, as shown in Figure 4. They are then packed neatly in shallow boxes for removal to the field where they are to be planted.

Various methods are employed for handling the plants in setting. As a rule, a line is used and the land marked to indicate the location of rows. Several methods are employed for marking the distance

between plants in the rows. A marking device much used by the Bermuda-onion growers in Texas consists of a sectional roller with the sections the same distance apart as the distance between the rows and each section provided with conical pins to form the holes in which the plants are set. The objection to the sectional roller marker is that it can not easily be drawn in a straight line and straight rows are essential to good cultivation.

After marking the land, the plants are dropped ahead of the planters, or they may be kept in the trays and simply removed as planted. The transplanting process consists mainly in pushing the root end of the seedling into the soil with one finger and then firming the soil about the plant. This work is very laborious and can only be performed economically by very cheap labor. A small plow, such as is generally included with the attachments of the wheel hoe (fig. 5), is often employed for opening a furrow in which to set the small onion plants. As the plants are set the soil is either drawn about them by hand, or the plow may again be used for this purpose. In the Bermuda-onion district the work of transplanting is as a rule done by contract. In transplanting, all inferior plants should be rejected, thus insuring a more nearly perfect stand and development.

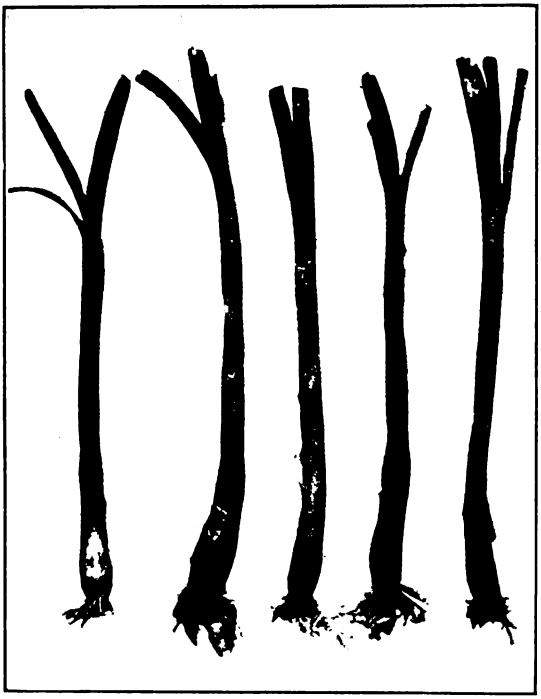

FIGURE 4.—Seedling onion plants trimmed ready for transplanting

PROPAGATION BY SETS

The use of sets is still another modification of the regular seedling method, in which the seed is planted one year to form the sets from which to grow a crop of mature onions the following year. Like the transplanting process the use of sets is limited in its application. Onions grown from sets will ripen earlier than those from seed sown in the field, but the use of sets for commercial onion growing is not so practical as transplanting seedlings, because of the high cost of sets. In planting onion sets a furrow about 2 inches deep is opened, the sets being dropped about 3 inches apart and firmly covered. The quantity of sets required to plant an acre will depend upon their individual size and planting distances, but it is generally between 15 and 22 bushels.

CULTIVATION

The cultural requirements of the onion are frequent shallow stirring of the soil and freedom from weeds. The feeding roots of the onion run close to the surface of the soil and should not be disturbed by deep cultivation. Sometimes a heavy rain immediately after seeding will so pack the surface that the seedlings can not break through. Under such circumstances it will be necessary to slightly break the surface by means of a steel rake or a rakelike attachment on a cultivator. As soon as the plants are up and the rows can be followed the cultivator should be started to loosen the soil, which is always more or less compacted during seeding.

HAND CULTIVATION

Where the rows are 14 inches or less apart, the work of caring for the crop must all be done by hand. For this purpose the wheel-hoe tools of various types are essential. These implements are provided with several kinds of hoes, cutters, and sweeps designed to work the soil away from the plants, to shave the surface and destroy weeds, and to stir the soil and work it back around the plants. Onions grown on muck and alluvial soils will require from 8 to 14 workings with the wheel-hoe implements; on sandy soils it will not be necessary to cultivate so frequently.

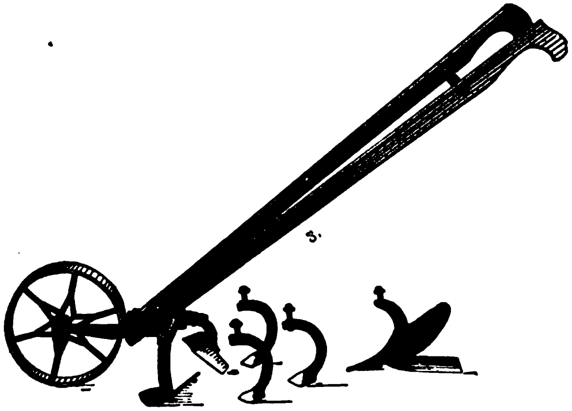

FIGURE 5.—Wheel hoe adapted to working onions

Several types of wheel hoe are in use, but those having a single wheel and passing between the rows are most desirable. Those of the type shown in Figure 5 are good. Many growers have designed special implements to suit the requirements of their soils; two of these are shown in Figure 6, the one designed to cut the soil away from the row and the other to stir and work the soil back to the row. Some of the growers in the onion fields near Chicago have adopted a hoe stock consisting of a pair of light plow handles, an iron stock, and the front wheel of a bicycle. To the stock of this device may be attached almost any form of sweep or cutter, and the implement is exceptionally easy to propel. The wide distance between the handles places the implement well under the control of the operator. Figure 7 gives an idea of the general appearance of this implement.

HORSE CULTIVATION

In sections where onions are grown on a soil that is not well adapted to hand culture the rows are placed 30 to 36 inches apart

and the cultivation is performed by means of horse-drawn tools. This is particularly true where onions are grown on the black waxy soils of Texas and other soils of the prairie type. As with hand culture, frequent shallow stirring of the soil is essential, the work generally being performed with one of the harrow-tooth cultivators. Those of the type shown in Figure 8 are well adapted to this work. An implement known as a weeder can be used for breaking the surface before the seedlings appear; also for general cultivation by removing a tooth at the point where the rows are located.

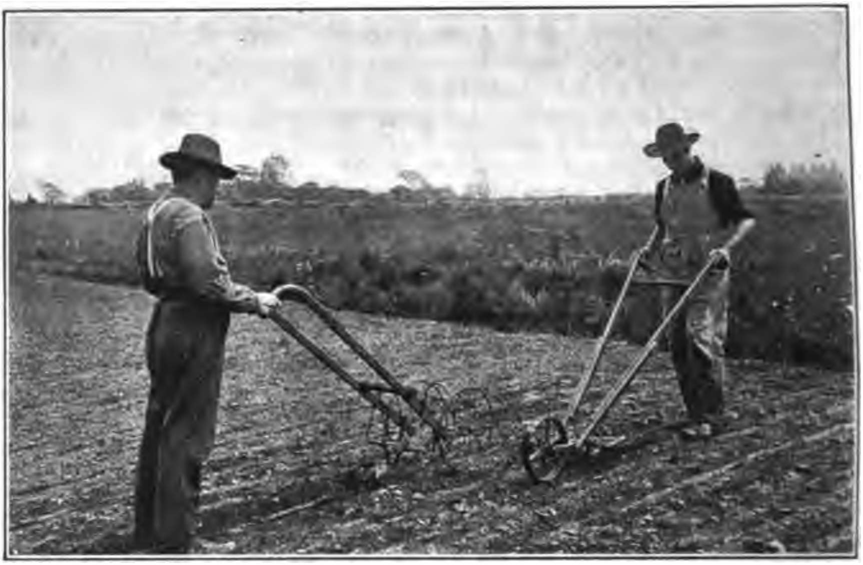

FIGURE 6.—Special wheel hoes for cultivating onions

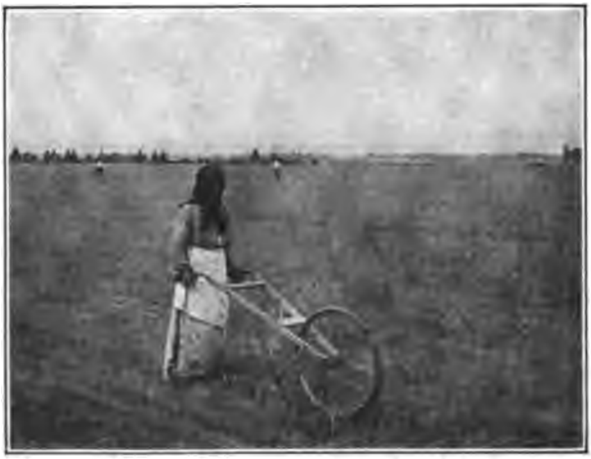

FIGURE 7.—High wheel type of hoe. (Patented)

HAND WEEDING

It is well-nigh impossible to produce a crop of onions without some hand weeding. During favorable seasons the strictly handwork may be reduced to but one or two weedings, but a greater number will be necessary during rainy seasons. Each hand weeding will cost from $5 to $12 an acre, according

to wages paid and the number of weeds present. The work of hand weeding may be facilitated by the use of some of the small hand tools designed for the purpose. Among these tools might be mentioned the onion hoe (fig. 9), the hand weeder (fig. 10), and the thinning or weeding hook (fig. 11). Girls and boys are expert at hand weeding, the practice being to work them in gangs of 10 to 20 with an overseer behind them to see that the work is properly done. In some localities the wages paid for this class of work are $1.50 to $2.50 a day.

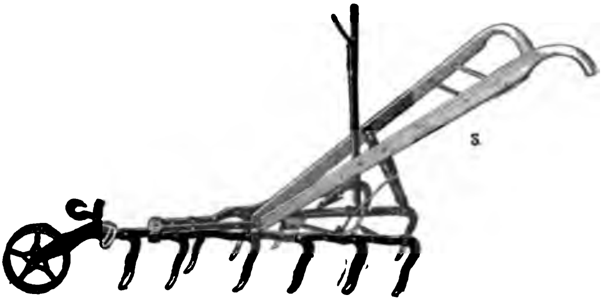

Figure 8.—Small-tooth horse cultivator

IRRIGATION

Outside of the areas where irrigation methods are depended upon for the production of general crops it is not customary to use artificial watering in the growing of onions. In a few cases the land has been equipped with overhead sprinkling systems which are employed to moisten the soil after the seed is planted and also during extremely dry weather. On peat and muck soils the young seedlings are frequently lost by the dry muck blowing with the high winds of early spring. In this way a part of the field may have the soil blown off to such an extent that the plants will be left without soil about them, while other portions of the field will be covered by 1 or 2 inches of loose muck. The use of a small quantity of water sprayed over the field will sometimes prevent this shifting of the soil during a windstorm but will not prevent the accumulation of muck blown on to the plants from adjacent nonirrigated areas. Sandy soils are also subject to the action of winds to a greater or less extent, and losses may be prevented by the timely application of water over the surface. In a few instances subirrigation is employed in the growing of onions.

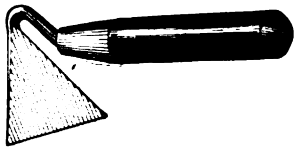

Figure 9.—Onion hoe

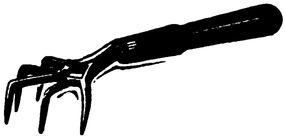

Figure 10.—Hand weeder

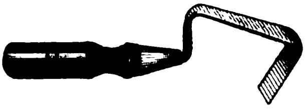

Figure 11.—Thinning or weeding hook

Throughout the Bermuda district of the Southwestern States surface irrigation is almost universally employed. The Bermuda onions are planted mostly in comparatively level beds with dividing ridges and are flooded once each week or 10 days during the growing period. About a week before the plants are set the soil is flooded

and then worked over with disk and smoothing harrows just ahead of the planters. Within a day or two after planting the land is again flooded and the surface water drawn off; this process is repeated, with alternate cultivations, as often as required. Toward the end of the growing season the water is withheld to allow the bulbs to ripen. As a rule about 10 waterings in all are required, at a cost of about $2.50 an acre for each watering, or $25 per acre altogether. Figures 12 and 13 give a good idea of the methods of applying the water in the Bermuda-onion growing district.

In the principal Bermuda-onion growing districts the water for irrigation purposes is obtained only after the expenditure of thousands of dollars for pipe lines and pumping machinery. The cost of watering as given above does not include any share of the original cost for installation or water charges, but covers only the labor.

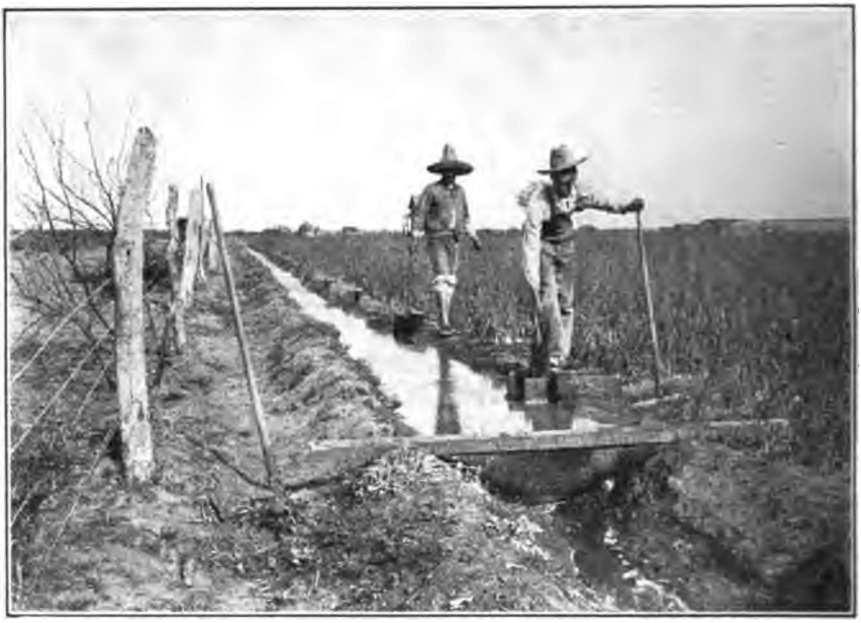

FIGURE 12.—Irrigation ditches in Bermuda-onion field in Texas

HARVESTING AND CURING

In the northern onion districts the crop ripens and is harvested during the latter part of the summer and early autumn. As a rule the work of harvesting onions begins late in July and is practically completed and the crop housed before October. In the Southern States, where the crop is grown during the winter, the harvesting and marketing period is during the spring and is practically ended before the northern product comes upon the market.

In the North the bulbs are allowed to become as ripe as possible before removing them from the soil. Growers prefer that the tops

ripen down and shrivel and that the outer skin of the bulbs be dry before they are pulled. Figure 14 shows a field of onions in prime condition for gathering. To the southward, where the onions are not cured so thoroughly, they are often pulled about the time that the tops begin to break and fall. The ripening process often may be hastened by rolling a very light roller or a barrel over the tops to break them down. This process is frequently spoken of as "barreling."

Where the bulbs are practically upon the surface they may be pulled by hand and thrown in windrows consisting of 8 or 10 onion rows. If the onion bulbs are considerably covered with soil it will be necessary to employ a 1-horse plow or a cultivator with a sweep attached for lifting them. In any case it will be necessary to gather them from the soil by hand. After lying in the windrows for several days and being stirred occasionally with wooden rakes, the tops are removed either by twisting or cutting with ordinary sheep shears. In cases where very bright color is important, as with fancy White Globe onions, and this would be injured by exposure to the sun and rain, the bulbs are cured in long, narrow, low ricks formed by placing several rows of onions laid with the bulbs to the center and the tops to the outside to protect the bulbs. As the tops are removed the bulbs are generally placed in crates for drying. Onion-topping machines frequently are employed, the bulbs being hauled from the field to a central location and run through the topper. These machines remove the tops, grade the bulbs, and deliver them into the crates or bags. If crates are not employed for curing, the bulbs are allowed to lie in the windrows for some time, and are then either

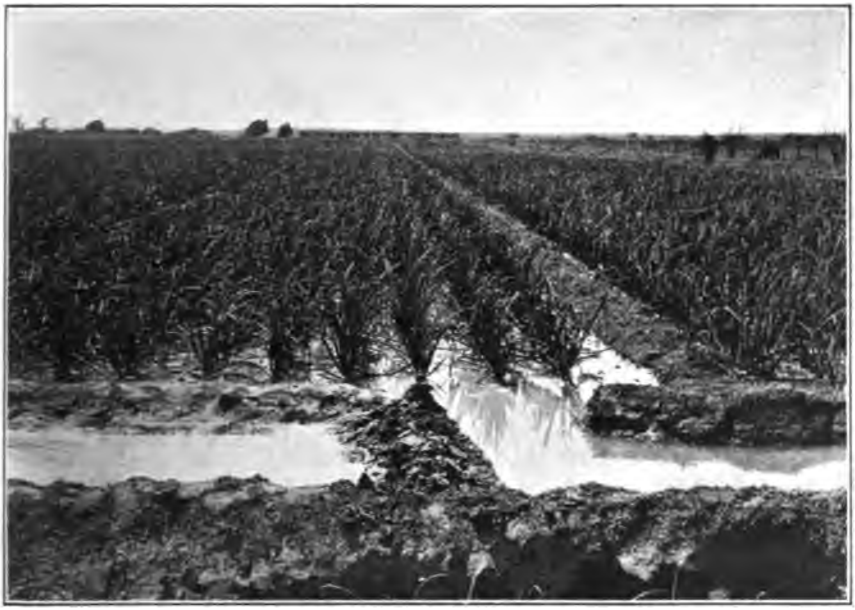

FIGURE 13.—Irrigation of Bermuda onions in Texas

put into sacks or hauled to slat cribs, where the curing process is completed. Too long exposure to hot sunshine will injure the bulbs. Figure 15 shows a field of onions drying in windrows, with crates ready for their removal from the field.

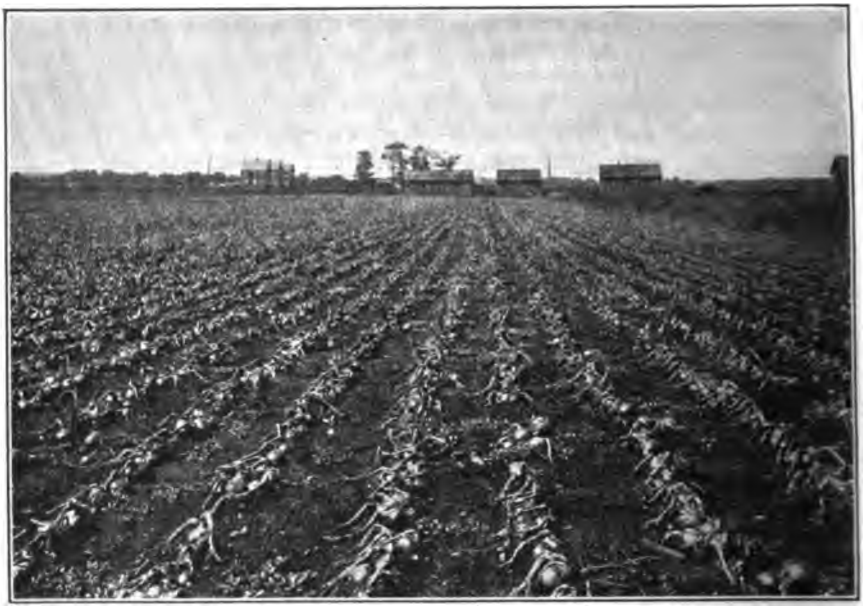

FIGURE 14.—Field of onions in condition for gathering

After gathering into crates, the crates are either stacked in the field, hauled to a central stacking yard where they are covered with boards or canvas, or hauled to open sheds and there piled one upon the other with numerous air spaces until the onions are thoroughly cured.

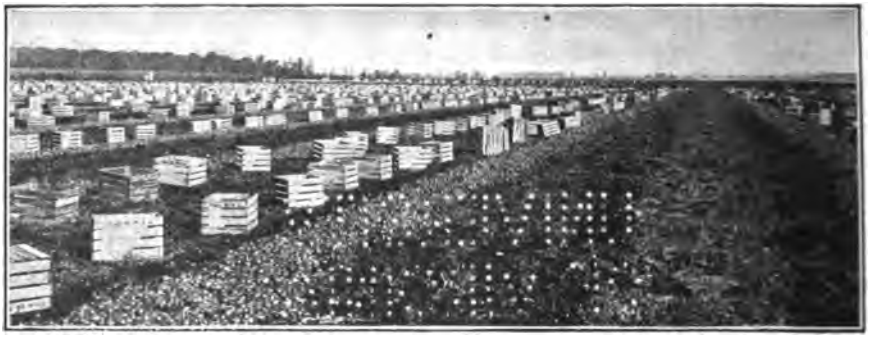

FIGURE 15.—Onions drying in windrows, showing crates used for curing and storing

Where the bulbs are extremely dry at the time of their removal from the soil, they may be allowed to lie in the windrows for a few days only, and then sorted and cleaned in the field ready for packing and marketing. Where onions are put into sacks and afterwards

allowed to remain in the field, the sacks should be supported on poles laid on the ground, as shown in Figure 16.

In the Bermuda-onion districts, where only a short curing process is given to the crop, it is the practice to pack and load into the cars as soon as possible after pulling and topping. When the shipping is at its height, it is not uncommon for onions that are pulled from the soil in the morning to be in the cars and on their way to market by evening; however, a portion of the crop is given a more thorough curing process, and the entire crop would be benefited by at least two days of curing before shipment.

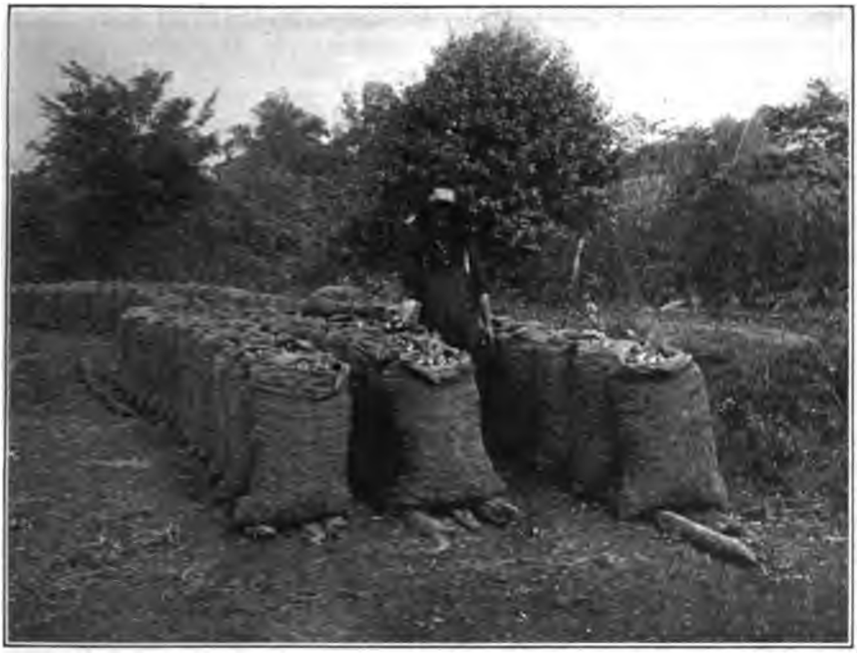

FIGURE 16.—Method of curing onions in sacks standing in the field

STORAGE

In order that onions should keep well when stored they must be well ripened and thoroughly cured. "Thick necks" or those that are immature, or soft, should never be placed in storage but should be sold as soon as gathered for whatever price they will bring. Good storage onions will rattle almost like blocks of wood when poured from one crate to another. In order that the bulbs may remain bright and of attractive appearance they should not be allowed to lie exposed to the weather, but should be hauled and stored in open sheds just as soon as they may safely be placed in 1-bushel crates.

After the bulbs have remained in drying sheds or cribs for four or five weeks they will be ready for screening and removal to the storehouse. In handling onions it is the rule to pass them over a screen each time they are moved, as in this way the loose skins are removed and any soft or decaying bulbs may be sorted out. When bags are

used for drying in the field, the onions are screened in the manner shown in Figure 17, and the bags refilled for hauling to the storage house.

The essentials for the successful storage of onions are suitable containers, plenty of ventilation, a comparatively low temperature, dryness, and safety from actual freezing. Any building wherein the above conditions may be secured will answer, but houses of the type shown in Figure 18, which are built especially for the purpose, are most satisfactory.

The construction of the storage house should be double throughout, with plenty of felt or paper lining. Both top and bottom ventilation should be provided, and the ventilator openings should have doors that may be closed to control the temperature. The floors are constructed of narrow planks with half-inch spaces between the planks for the passage of air. Bottom ventilation is frequently secured by means of drainpipes built into the foundation at the surface of the ground. These pipes are carried some distance toward the center of the house and discharge the cool air at a point where it is most needed.

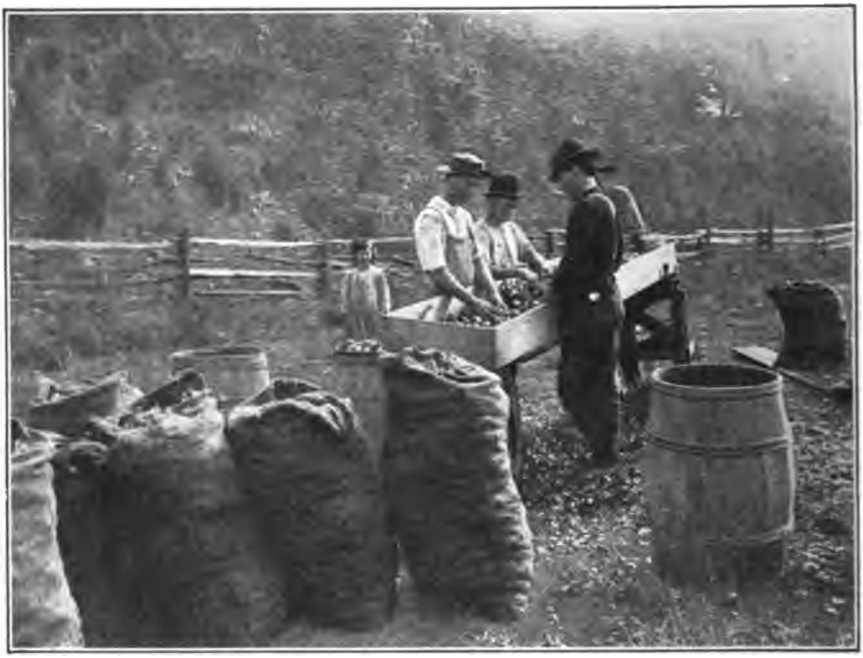

FIGURE 17.—Grading onions in the field by means of a screen

The temperature of the storage house should be carried as low as possible without actual freezing. During extremely cold weather the ventilator openings and doors should be kept closed to keep out cold air, and after the onions have become thoroughly chilled the house should be kept closed in order to hold the temperature down and prevent the entrance of moisture during warm or rainy periods.

Damp, foggy weather is injurious to onions, especially if it follows a period of cold, and will cause the bulbs to become covered with moisture if the outside air is admitted. A little artificial heat from a stove or radiator may be required during excessively cold weather, but so long as the temperature in the house does not fall below 32° F. there will be no danger of injury. A temperature of 36° to 38° will give good results.

The best method of storing onions is in standard-size slat crates 20 inches long, 16 inches wide, and 14 inches deep, outside measurements. The material for the sides and bottom is about three-eighths inch thick and 2½ inches wide, four pieces being used to form a side. The corners are reinforced on the inside by means of 3-cornered pieces of oak, to which the slats are nailed. These dimensions provide crates that are interchangeable, the width of five being equal to the length of four. The crates will also nest together when empty, with one inside of two turned together. The full crates are stacked in the storehouse with 1 by 3 inch strips between them to allow for the circulation of air, as shown in Figure 19.

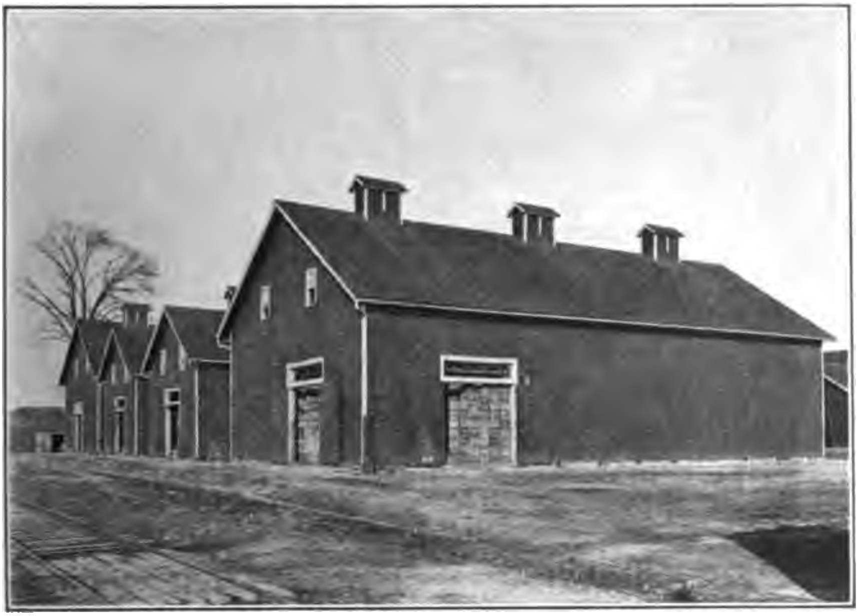

FIGURE 18.—Onion storehouses

Onions are sometimes stored in slat bins holding 100 to 300 bushels each. Bags are also used to some extent, but neither bags nor bins are as satisfactory as the crates, on account of the difficulty in providing the necessary ventilation and change of air through the onions. Bulbs stored in bags or bins must be more thoroughly cured than those stored in crates. There are single large storehouses in use that will accommodate 50,000 to 60,000 bushels of onions when stored in crates.

MARKETING[1]

Large quantities of onions are sold and shipped direct from the fields where they are grown. A part of the crop is held in temporary storage until late autumn or early winter. During recent years the winter storage of onions has become of great importance, and the finest stock is held for late-winter deliveries. The Bermuda crop from the southwestern part of the country comes on the market during April and May, so that most of the storage onions are disposed of before that time.

In marketing onions the first essential is to properly grade and clean the bulbs, in order that they may present an attractive appearance when offered for sale. Ordinarily the bulbs are separated into three grades—primes, seconds, and picklers. The primes include all of those 1¼ inches in diameter and larger, and the seconds consist of those from three-quarters of an inch to 1¼ inches in diameter, while all those that will pass through a ¾-inch screen are sold for pickling purposes. The grading is generally done in the field during the cleaning process, but as onions shrink considerably while in storage it is necessary to regrade before placing upon the market. The type of screen used for grading onions is shown in Figure 20. For cleaning the pickling onions an ordinary fanning mill is employed, special screens being provided for the purpose.

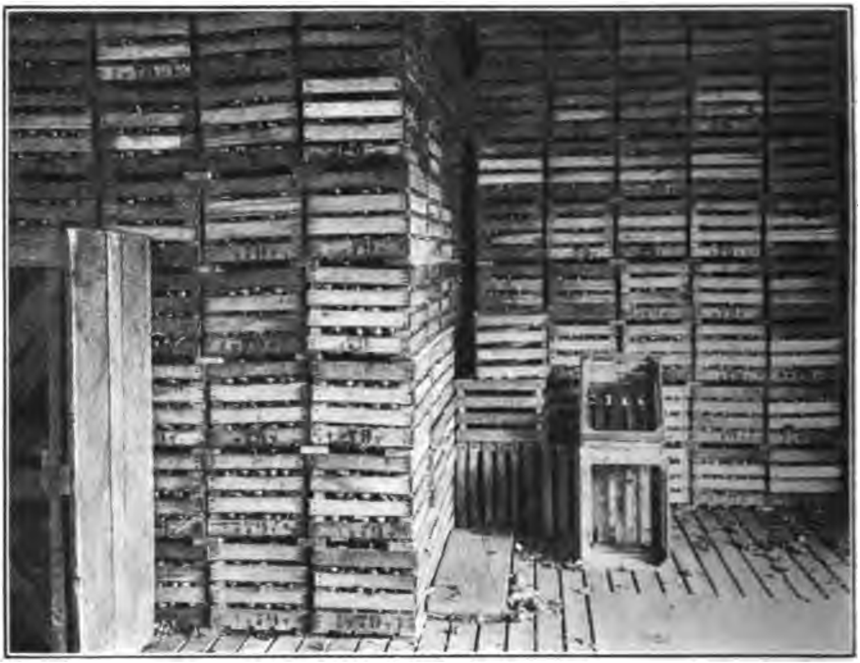

FIGURE 19.—Inside of storage house, showing method of stacking crates

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[1] For detailed information on the marketing of onions, see the following: United States Department of Agriculture Bulletins No. 1283, The Marketing and Distribution of American-Grown Bermuda Onions, and No. 1325, Marketing Onions. No. 1325 is out of print, but may be consulted in libraries.

Onions are placed upon the market in 1-bushel crates, bags, barrels, 1-bushel hampers and baskets, and in bulk. The folding crate, shown in the foreground of Figure 20, is undoubtedly the most attractive package in use for marketing onions. The bags employed are of special open-mesh weave and hold 100 pounds. Onions are sometimes shipped loosely in cars and shoveled into barrels or bags at their destination.

The legal weight of dry onions is generally considered 56 pounds to the standard bushel, although this varies somewhat in different States.

COMMERCIAL VARIETIES

For trade purposes onions are divided into two large classes—"strong" onions and "mild" onions. Each of these classes may again be divided into four color classes—white, yellow, brown, and red—and each of these color classes into those which will produce bulbs when the days are short (12 hours or shorter) and those which require long days (13 hours or longer) for bulb formation.

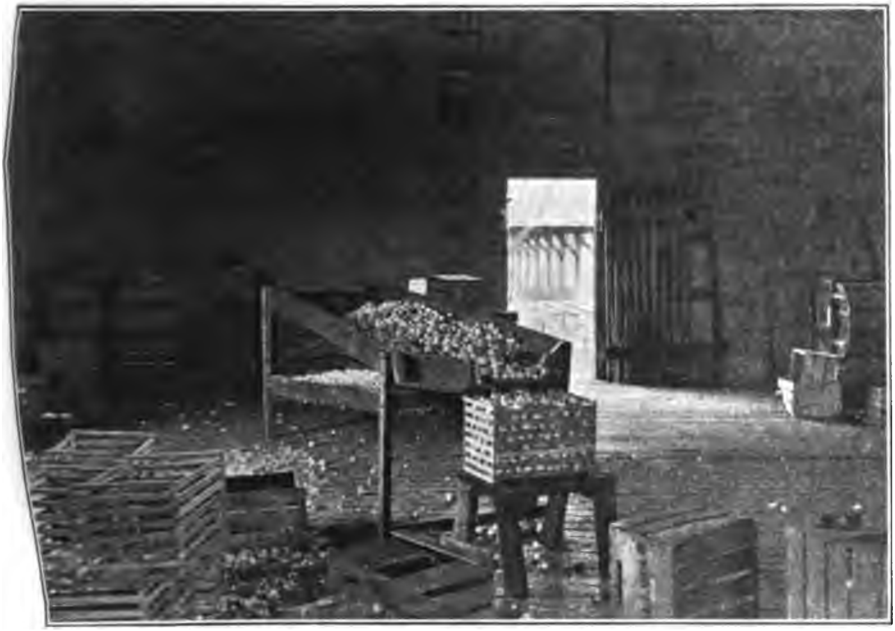

FIGURE 20.—Screen used for grading and cleaning onions, showing folding crates sometimes used for marketing.

The short-day varieties are the ones adapted to the South or other regions of the country where they may be grown through the winter, and since they form bulbs when the days are relatively short, they mature before the long-day varieties. The most important mild-fleshed, short-day varieties are Yellow Bermuda (pale yellow), Crystal Wax (white), and Early Grano (pale yellow). Red Creole and White Creole are the common "strong" short-day varieties and, unlike Yellow Bermudas and Crystal Wax, are excellent storage varieties. None of these varieties are recommended for culture in the North, where seed is sown in the field in the spring, as they mature so quickly that the bulbs are usually very small.

Sweet Spanish or Valencia is the mildest flavored of long-day varieties, a fair storage onion of large size, yellow skin, and late maturity, and somewhat resistant to thrips.

The strong, long-day varieties are mainly grown in the major main-crop or storage-crop sections of the northern part of the United States. These varieties differ in season of maturity, shape, and color as follows: Early Yellow Globe (early, round), Ebenezer or Japanese (early, flattened, yellow), Yellow Globe Danvers and Ohio or Michigan Yellow Globe (midseason, round), Stockton Yellow Globe (California midseason, round), Southport Yellow Globe (late, round oval), Red Wethersfield (midseason, flat round), Southport Red Globe (late, round, oval), White Portugal (midseason, flat round), Southport White Globe (late, round, oval), and Australian Brown (late, round, small).

In the selection of varieties for any particular locality the soil and climatic conditions and market requirements should both be considered. Those adapted to the muck soils are the yellow and red sorts. For alluvial and prairie soils the red and brown varieties are to be preferred while all kinds do well on the sandy loams and light soils. A cleaner, better grade of white onions can generally be produced on light or sandy soils than on muck or clay loams. Those of the Bermuda, Spanish, and Egyptian types flourish on the deep, rich alluvial soils of the river bottoms and delta regions.

Certain of our markets show a decided preference for onions belonging to a particular type. The red and brown varieties find ready sale on the markets of the Middle West, while onions of the yellow and white varieties are preferred in the eastern cities. Onions will withstand long-distance shipment, those of the mild type being generally more subject to injury than the strong sorts. Some of the white varieties also have a thin skin and are easily injured. It should be the aim of every grower to employ varieties that will withstand handling and at the same time find ready sale on the market.

The top or tree onion, which reproduces by means of small bulblets formed on the top of the seedstalk, is extensively used in the production of early-spring bunching onions.

The multiplier or potato onion reproduces by a division of the bulbs. In growing this variety it is necessary to plant large bulbs to produce sets for the next year's planting and small bulbs or sets for the crop of large onions. The bulbs of this variety may remain in the soil year after year and are desirable for use early in spring.

PRODUCTION OF BERMUDA ONIONS

Bermuda onions are now an important commercial crop in Texas and California, with small plantings in a number of the Southern States. The Bermuda onion fields of Texas are located around Laredo and other points in or near the Rio Grande Valley.

SOILS AND CLIMATE ADAPTED TO THE BERMUDA ONION

Soils of a silty or alluvial nature are suited to the production of Bermuda onions, and those containing considerable sand are most desirable. As already noted in referring to fertilizers for onions, the Bermuda requires a very rich soil for the best results, and this can only be obtained by first selecting a good soil and then manuring heavily. The Bermuda onion as grown in this country is a winter crop; therefore, mild climatic conditions are required. While the plants would withstand considerable freezing, their growth is seriously checked by cold weather, and the crop will not mature in time for the early market if grown to the northward.

CULTURAL METHODS

The cultural methods employed in the growing of Bermuda onions are essentially the same as those for ordinary onions. As the greater portion of the crop is grown in a region which has no regular rainfall, irrigation methods are employed almost universally. The greater part of the crop is grown by the transplanting process and a great amount of hand labor is required. The seeds are sown in specially prepared outdoor beds from the middle of September to the middle of October, and the seedlings are transplanted to the field November 20 to January 10, or even later. From 3½ to 4½ pounds of seed are required for each acre to be planted; this will allow for discarding all the weaker plants. The plants are allowed to remain in the seed bed until they are from three-sixteenths to one-fourth inch in diameter before they are transplanted. As the seedlings are lifted the greater portion of both the small roots and the tops is trimmed off in order that they may be transplanted more readily. (Fig. 4.)

HARVESTING AND MARKETING

Bermuda onions are harvested as early as possible, generally before the tops have become fully ripened. For removing the bulbs from the ground a 1-horse plow, a potato digger, or a cultivator with a cutter wing attached is employed. The bulbs are then separated from the soil by hand, the tops cut off with shears, and the onions thrown in windrows or piles to dry in practically the same manner as for the regular-crop onions in the North. After the bulbs have become thoroughly dry on the surface they are either placed directly in the crates for shipment or are carried to a packing shed to be graded and packed for market.

During the early days of the Bermuda-onion industry the crop was shipped largely in bags, but it was soon found that the bulbs were too perishable for this method of handling. At present the greater portion of the crop is sent to market in folding slat crates that are about 20 inches long, 12 inches wide, and 12 inches high.

These crates hold approximately 50 pounds of onions and weigh 56 or 57 pounds when filled. The cost of these crates is about $20 a hundred, but they add enough to the attractiveness and carrying qualities of the onions to make their use profitable.

YIELD OF BERMUDA ONIONS AND PRICES OBTAINED

Phenomenal yields of 34,000 and 35,000 pounds of Bermuda onions are frequently made on an acre of land, but this is far above the general average, which is in the neighborhood of 10,000 or 12,000 pounds to the acre. Many fields, especially when planted for the

first time, do not yield as much as 10,000 pounds to the acre. On land that has been heavily manured and planted to onions for several years the yield averages about 16,000 pounds.

The best Bermuda-onion farms are valued at $300 to $500 an acre. In order to prove profitable, the growing of Bermuda onions should be conducted on a comparatively large scale. The necessary land and irrigation facilities will require the initial outlay of from $10,000 to $30,000, and the running expenses are quite heavy. Labor can be secured at a low price, but is correspondingly inefficient and often not to be had in sufficient quantities. Furthermore, the markets are now pretty well supplied with Bermuda onions, and persons who desire to engage in their production are advised to investigate every phase of the industry before embarking too heavily in it. The expansion of the Bermuda-onion industry is limited by the facts that a large supply of bulbs can be grown on a comparatively small area, that the distance to market is great, that the product is perishable, and that the markets will consume only a limited quantity at the prices at which the crop can be sold with profit.

GREEN ONIONS FOR BUNCHING

Another phase of onion culture that is of considerable importance in certain localities is the production of young bunching onions for the early spring trade. In several sections along the South Atlantic coast the growing of this class of onions is quite an enterprise. Many persons who are engaged in other lines of work follow the practice of growing a small area of bunching onions as a side issue.

The varieties known as multipliers and top onions are generally employed for this purpose; however, bunching onions are sometimes grown from ordinary sets, from inferior and damaged large onions. and from seed.

CULTURAL METHODS

For growing bunching onions the bulbs or sets are planted during the autumn either in beds or in rows 12 or 14 inches apart with the bulbs quite close in the rows. The bulbs will start growing within a short time and make more or less growth during the winter. As soon as the weather becomes warm during the first months of spring the onions make a rapid growth and are ready for marketing about the time peach trees begin to bloom.

The land upon which these onions are grown should be rich and mellow, but very little actual cultivation will be required. Where the winters are severe it may be necessary to provide slight protection, either a little straw, loose manure, leaves, pine straw, or corn fodder that has been run through a shredder. If the onion beds are protected on the windward sides by means of a windbreak consisting of a grove of pine trees, a fence of boards, pine boughs, or corn fodder, the crop will be ready for marketing a little earlier than if left exposed. Multiplier onions not gathered for marketing are allowed to remain to form the bulbs for planting the following season.

MARKETING

In marketing this class of onions the young scallions are pulled, the roots trimmed, and the outside peeled off, leaving the stem white and clean. They are then tied in small bunches by means of soft white string, the tops trimmed slightly, and the bunches packed in crates or baskets for shipment or for sale on the local market. This phase of the onion industry is limited to small plantings and is well suited to the general market garden.

During the spring and early summer large quantities of ordinary young onions are pulled when the bulb is about the size of a 50-cent piece, the roots and tops are trimmed, and they are then bunched and sold for stewing purposes. So far as known, this class of onions is not shipped to any great extent, but is sold mainly on local markets.

GARLIC AND LEEKS

Garlic is closely allied to the onion, but will remain in the ground from one year to another in a mild climate if undisturbed. Garlic is planted by setting the small bulbs, or cloves, in either the autumn or early spring. The culture is practically the same as for the onion.

The leek also belongs to the same class as does the onion, but requires somewhat different treatment. The seed is usually sown in beds and the plants transplanted about 4 inches apart in the row. The plants of the leek are given about the same cultivation as onions, except that after they have attained almost full size the soil is drawn around them to a height of 6 or 8 inches to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored in cellars for winter use.

DISEASES OF THE ONION

The onion crop of the United States is by no means free from disease. For information regarding such diseases and measures of control, the reader is referred to Farmers' Bulletin 1060, Onion Diseases and Their Control, published by the United States Department of Agriculture, Washington, D. C.

ONION INSECTS AND THEIR CONTROL

In the United States the onion crop has only two serious insect pests. Of these, the onion thrips (*Thrips tabaci* Lind), because of its distribution over the entire country, is probably the most injurious. It is nearly always present on onions, and under favorable conditions it may increase to such an extent as to become very destructive. The onion thrips is a very small louselike insect, pale brown in color, and usually is first noticed because of the minute whitish spots which it leaves on the tips of the foliage after rasping away part of the leaf surface in feeding. The eggs are laid just beneath the surface of the leaf, and the insects, in both the mature and immature forms, feed on the surface from the sheath to the tip. In serious infestations the tops of the onions become grayish white, afterwards turning brown and dying. At such times the leaves, if examined, may be seen to be covered with thrips.

The onion thrips is particularly injurious in the South, and in the Texas Bermuda-onion district it is a constant menace to the crop. It is particularly likely to injure plantings which follow or are adjacent to such early crops as cabbage, from which the thrips migrate in great numbers at harvest time. A vigorous, strongly growing onion crop may grow away from thrips injury, but if for any reason growth becomes badly checked, damage is almost sure to result.

Recent experiments [2] have shown that the thrips can be controlled and the yield materially increased by the use of naphthalene dust. Crude naphthalene is crushed with a heavy roller on a cement floor and sifted through a 50-mesh screen. Forty pounds of the naphthalene is mixed with 60 pounds of hydrated lime. To be most effective the dust should be allowed to stand in a tight container for at least 24 hours.

The dust is applied at the rate of 200 pounds to the acre. The first application should be made when the injury first becomes apparent and repeated at intervals of about a week. The dust is applied with a rotary hand duster or with a power duster attached to a garden tractor. The dust is directed into the crown of the plants. The applications should be made in the morning while the air is still and the plants are wet with dew. From 3 to 5 applications, depending on the severity of the infestation, are required.

Thrips may be fairly well controlled by spraying with nicotine at the rate of three-fourths of a pint of a 40-percent solution to 50 gallons of water in which 4 pounds of soap has been dissolved. Use a high-pressure sprayer and hold the nozzle close to the plants, as thrips often feed and remain protected in the leaf sheaths and creases. Clean up weed patches near the onion fields and rake together and burn the onion tops as soon as the crop is harvested. The grower should examine his onion plantings from time to time in order to detect the early stages of the infestation. It is easier to keep an infestation down by early treatments than to control a heavy infestation.

In the northern part of the United States the onion maggot (*Hylemyia antiqua* Meig.) often becomes very destructive, especially to small seedling onions. This pest is a white, footless maggot, the larva or young of a fly much resembling the common house fly, and is about three-eighths of an inch in length when full grown. The eggs are laid by the fly early in the spring, and are placed, in the case of seedling onions, on the ground near the plant, or in the sheaths of the leaves near the ground. On hatching, the young maggot burrows into the plant and bores through the stem and bulb, easily killing small seedlings. After killing one plant it proceeds to the next, thus causing many skips in the row. When larger plants are attacked, several larvae may be found in the bulb.

A remedy that has been used successfully in some sections consists of treating the soil about the plants with a bordeaux-oil emulsion. The emulsion is best applied to the onion rows by means of a sprayer, the material being directed to the base of the plants. Enough of the material should be applied to moisten the soil at the base of the plants. The bordeaux-oil emulsion may be prepared by adding 1½ gallons of oil emulsion, suitable for use against orchard scale insects, to 48½ gallons of 4-4-50 bordeaux mixture. Apply five times at weekly intervals, beginning when the young plants are about an inch high. An effective treatment requires about 115 gallons of the spray per acre.

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[2] Cornell University Extension Bulletin 206, Diseases and Insects Affecting Vegetable Crops.

Cutworms are sometimes troublesome, but are easily controlled by the bran mash and arsenic bait, scattered thinly wherever the young seedlings have been found to be cut off.[3]

PRESENT STATUS OF THE ONION INDUSTRY

Because of variations in the cost of labor, tools, fertilizers, seed, and other materials and the many factors involved in the production of an onion crop it is impossible to give definite cost and profit figures. The average yield of onions is around 290 bushels to the acre, but yields of 400 to 600 bushels are not uncommon. The price of onions is extremely variable from one year with another, but on the whole the crop has proved profitable to the growers when taken on an average for a period of years.

In some sections onions are grown in rows 3 feet apart and given horse cultivation, thus reducing the yield to about 150 bushels on an acre and cutting down production costs in proportion. This method of growing onions is especially adapted for use on low-priced land and where hand labor is scarce.

Both the supply and demand for onions are increasing and at present bear about an equal relation to each other. Some years the supply falls a little short and the prices go somewhat higher, with the result that larger quantities are imported. The following season the plantings are generally heavier, the market may be a little slow, and the result will be low prices, and a great many people will discontinue the growing of onions or reduce their acreage.

Prices of onions, especially the Texas-grown Bermuda onions, are greatly influenced by importations of Egyptian onions which appear on our markets about the same time of the year that the Bermuda onions are being marketed. The ease with which both the Egyptian and the Spanish onions can be delivered to our eastern markets as compared with the long freight haul from southwestern Texas or Pacific Coast States renders the position of the American grower of Bermuda and other mild onions more or less hazardous. Despite this condition, however, both the Bermuda and the Spanish onion industries have become well established in the United States. The American grower of Bermuda onions is still dependent upon the Canary Islands for his seed supply.

Recently the production of the large Sweet Spanish or Valencia type onion has become well established in a number of the Western States, and with the present tariff rate in effect on imported Spanish and other onions American growers are in position, under normal crop conditions, to fully supply the principal markets of the United States. American growers of the Sweet Spanish or Valencia type onions are no longer dependent upon imported seed, as an adequate supply is now being produced by the California and other western seed growers.

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[3] For further information write to the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

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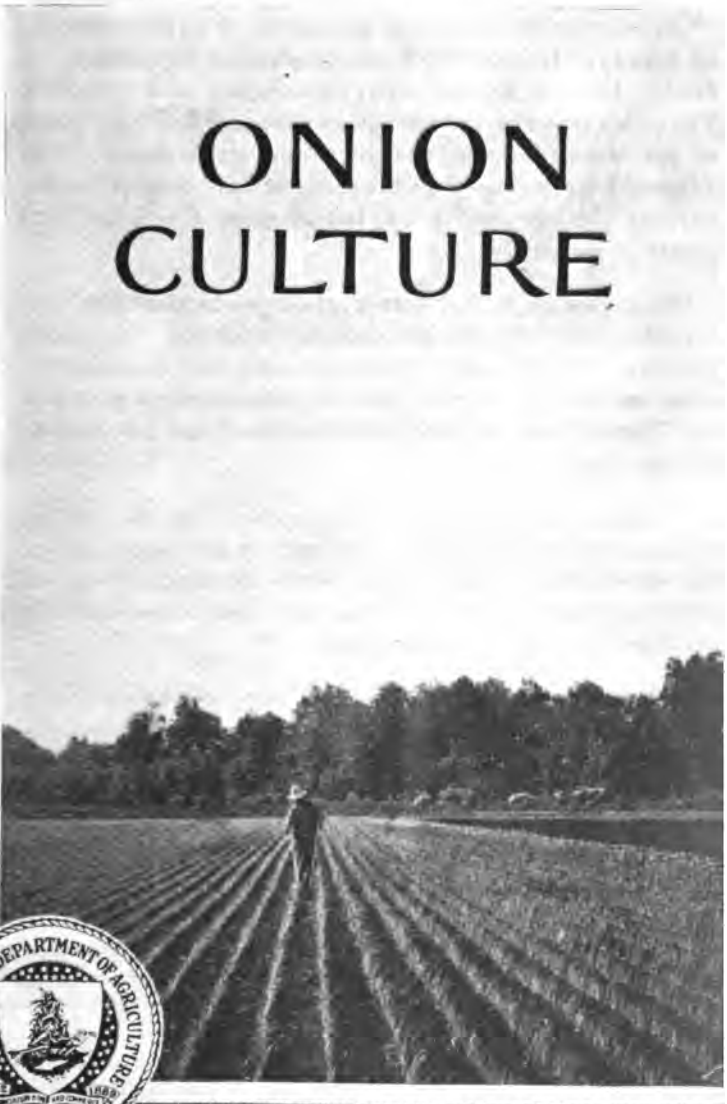
FARMERS' BULLETIN No. 354

ONION CULTURE



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THE ONION, in one or more of its several forms, has been in use throughout all time of which we have authentic history. It is of Old World origin, but was brought to North America by the early discoverers and colonists. The onion is grown universally in home gardens and is one of our important market-garden and truck crops. It is adapted for growing on a wide range of soil types and under varying climatic conditions, but requires a rich soil and plenty of moisture.

Onions are an intensive crop, their production involving considerable hand labor but yielding a relatively high return per acre. Prices received by the growers vary considerably from one year to another, but the production of onions in the United States is fairly well stabilized and adjusted to market demands.

Recently there has been developed in several of the Western States a specialized industry in the production of the Sweet Spanish onion. The Bermuda-onion industry of southern Texas and California has been expanded and extended to several other sections.

The production and shipment of large numbers of early seedling onion plants by southern plant growers has to a certain degree replaced the use of onion sets for planting in home gardens and for a portion of the northern early market crop.

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ONION CULTURE

By W. R. Beattie, *senior horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

CONTENTS

Page
- Introduction 1
- Climatic requirements 2
- Soils adapted to onion culture 3
- Cultural methods 4
  - Preparation of new land 4
  - Crop rotation 4
  - Preparation of the soil 5
  - Fertilizers 6
  - Planting 8
  - Cultivation 11
  - Irrigation 13
- Harvesting and curing 14
- Storage 17
- Marketing 20
- Commercial varieties 20

Page
- Production of Bermuda onions 22
  - Soils and climate adapted to the Bermuda onion 22
  - Cultural methods 22
  - Harvesting and marketing 22
  - Yield of Bermuda onions and prices obtained 23
- Green onions for bunching 23
  - Cultural methods 23
  - Marketing 24
- Garlic and leeks 24
- Diseases of the onion 24
- Onion insects and their control 24
- Present status of the onion industry 26

INTRODUCTION

THE ONION is one of the important market-garden and truck crops in the United States and is very generally grown in home gardens. It thrives best on alluvial and drained muck soils under a temperate climate, but may be grown under a very wide range of soil and climatic conditions. Onions are grown to perfection on the alluvial soils of the Nile River Valley in Egypt, under the sea breezes of the South Sea Islands, on the delta lands along the seacoast, on sandy uplands, in the arid regions under irrigation, and on reclaimed swamp lands. There is perhaps no extensive area in the United States or its possessions where the onion, in one or more of its forms, cannot be successfully grown, at least for home and local use.

The onion is of Old World origin and has been used as a food plant from the earliest historic times. It was an important article of diet in Egypt at the time of the building of the pyramids, and Moses, in his account of the exodus of the Children of Israel from Egypt, mentions it as one of the articles of food for which the Israelites longed during their sojourn in the wilderness.

Onions were brought to North America by the early discoverers and became one of the common crops of colonial gardens. Commercial onion culture in its present form has developed mainly during the last 40 or 50 years. Formerly the production of onions for sale was confined principally to the New England States, but the industry soon spread to other sections, and when the vast muck areas of the Great Lakes and other regions were drained and brought under cultivation the onion soon became one of the most important crops on these soils.

At present the principal commercial onion-growing centers are located in New England, especially in the Connecticut River Valley, in northern New Jersey, southeastern New York, the entire Great Lakes region, and as far west as Minnesota. The production of Creole onions centers around New Orleans, La., and the greater part of the Bermuda-onion crop is grown in southwestern Texas and in California. Within the last few years the production of the Sweet Spanish onion has developed in several of the Western States, including New Mexico, California, Arizona, Utah, Nevada, Washington, and Oregon. In addition there are many local areas in the United States where onions are being grown in considerable quantities for the market.

The production of several crops closely related to the onion, such as chives, shallot, leek, and garlic, has been developed around local centers, especially in connection with market gardening near the large cities. Garlic might be mentioned as an exception, because it is produced mainly in a few localities where soil and climate are especially suitable for its growth.

The present acreage and production of onions in the United States are about equal to market demands. During years of short crops and low yields there is a shortage of onions with consequent high prices, but during years of heavy crops the supply, as a rule, exceeds the demand, and frequently prices are too low for profitable returns to the grower.

CLIMATIC REQUIREMENTS

For best results a temperate climate without great extremes of heat and cold should be selected. Onion culture is rarely profitable in regions where the climate does not change or has no definite seasons of heat and cold or moisture and drought. The onion does best under rather cool conditions, with plenty of moisture during its early stages, but requires a reasonable degree of heat, together with dryness of both soil and atmosphere, for its proper ripening. Where the onion industry has become established in the extreme southern part of the United States, the growing season is during the late autumn and winter, the crop maturing during the spring and early summer. If the crop matures at a time when there is considerable rainfall, it will be impossible to cure the bulbs without artificial means and they will be lacking in keeping qualities.

Certain types and varieties of onions, including the top onions and the multipliers or potato onions, are extremely hardy and may remain in the open ground throughout the winters of our Northern States, especially if given slight protection. These types are, however, not adapted to growing for market, except as green onions, "peelers," or "bunchers," to be sold during the early springtime. In certain sections of the South Atlantic coast region large areas of the top and multiplier onions are grown for this purpose. There is also a marked difference in the day-length requirements of the standard commercial sorts, some being adapted to growing far northward, while others, like the Bermuda and Creole types, do best in restricted southern localities.

The period required for the production of a crop of onions will depend upon the season, the methods employed in growing, and the

variety. If grown from seed, a period of from 130 to 150 days will be required. If from sets, the crop often may be matured in 100 days. If grown in the extreme northern part of the United States, where the seasons are short, the crop will mature more rapidly than to the southward. In the case of the Bermuda onion, as grown in Texas, the growing season extends from October to the following March or April.

Onions require an abundance of moisture during the early stages of their growth, but should be ripened under comparatively dry conditions. In most sections the seed is sown at a time of the year when frequent spring rains occur. Their period of greatest growth is during the early part of the summer, and the crop is ripened late in the summer when drying conditions may be expected. In irrigated regions the application of water is almost entirely under the control of the grower. During the active period of growth the water is applied about once a week, the soil being thoroughly soaked and the surplus water drawn off.

The amount of rainfall or irrigation required for the production of a crop of onions will depend largely upon the character of the soil and its drainage. Many of the peat or muck soils in which the soil water remains near the surface will require very little rainfall; in fact, the best crops of onions are produced on these soils during seasons of comparatively light but evenly distributed rainfall. Sandy and loose soils generally will require a greater amount of water, especially during the early part of the season.

SOILS ADAPTED TO ONION CULTURE

The essential requirements of a soil upon which to grow onions profitably are a high state of fertility, good mechanical condition in order that the crop may be easily worked, sufficient drainage, and freedom from weeds. If a soil has the proper mechanical properties—that is, if it contains sufficient sand and humus to be easily worked, is retentive of moisture and fertilizers, and is capable of drainage—all other requirements can be met. At least three types of soil are being extensively planted to onions in this country, the one common essential being proper mechanical condition.

Clay and alluvial loam soils abound in the river valley and delta regions near the coast. These soils are generally very fertile, but may require the addition of humus or stable manure in order to lighten them. The greatest difficulty encountered in growing onions upon land of this character is the tendency of the soil to run together and bake after hard rains. This is especially injurious after the seed has been sown and before the small plants have attained sufficient size to permit of stirring the soil about them. Where these soils contain considerable sand they are ideal for onion culture. Soils of this type are easily injured by plowing or working while wet.

Sandy soils, especially where underlaid by a well-drained clay subsoil, are often well adapted to onions. Soils of this character generally require heavy applications of fertilizers before they will produce a paying crop, but the quality of the product is excellent. Onions grown on sandy loams are generally solid, heavy, and of excellent keeping quality. Where sandy soils are lacking in humus

this may often be applied by means of crops of legumes grown upon the land and plowed under.

Throughout the north-central part of the United States and the delta region of California there are vast tracts of peat or muck soils that are being utilized for the production of the commercial onion crop. Before planting to onions, however, these soils must be cleared, drained, and brought to a suitable state of cultivation. In many cases this process will require two or three years' time, but sometimes the soil can be broken during the early winter, allowed to lie exposed to the action of frost, then worked down and planted to onions the following spring. The store of plant food in muck soil is usually large, but often it is not in available condition, and heavy applications of manure and commercial fertilizers, especially superphosphate and potash, are essential to profitable crops.

CULTURAL METHODS

The onion belongs to that class of crops that gives best results under very intensive culture, and the greatest yields are secured where a moderate acreage is planted and the work conducted in a most thorough manner. There is nothing technical about the growing of onions, but close attention and frequent cultivation are essential. Once the weeds get a start, the cost of production will be greatly increased, or the crop may be lost altogether.

PREPARATION OF NEW LAND

As a general rule new land is not adapted to onion growing until it has been worked one or two years with other crops. Onions should follow some row crop that has been kept free from weeds the previous season. Corn, beans, and potatoes are suitable crops with which to precede onions. Muck and sandy soils may in some cases be brought to a suitable condition for onions the first season, but the fitting will have to be very thoroughly performed. The land should be plowed in the autumn, then replowed in the spring, after which numerous harrowings and doubtless some hand work will be required to get the soil in suitable shape.

If necessary to manure the land heavily before planting to onions, it will be desirable to plant to some farm crop one season, then apply the manure during the autumn in order to give it time to become incorporated with the soil. Owing to the value of good onion land it would not be advisable to devote it to general farm crops for any extended period, although corn is frequently planted and oats or rye are sometimes used in the North. Cowpeas may be of great service in bringing new land into shape for planting to onions.

CROP ROTATION

Onions should not be planted on the same piece of land year after year, but some system of crop rotation should be maintained. Care should be taken, however, to use crops in a rotation that will not be exhaustive of the high fertility necessary in the onion land. During the years when the land is not devoted to onions it can be planted to some truck crop that will give a return that will justify the appli-

cation of large quantities of fertilizers, or, better, to a leguminous crop to be turned under as green manure. Continuous cropping with onions will cause the land to become infested with both disease and insect enemies that will sooner or later injure the crop to such an extent as to render it unprofitable.

PREPARATION OF THE SOIL

Assuming that the land intended for planting to onions is capable of being brought to a good mechanical condition, is fertile, well drained, and reasonably free from weed seeds, the first step in the production of the crop will be to plow moderately deep, then harrow, disk, roll, and drag until the soil is smooth and mellow to a depth of 5 to 7 inches. The method of preparing the soil will depend somewhat upon its character, the manner of planting to be followed, and the requirements for irrigation. There are few truck or other crops that require so careful fitting of the soil as do onions, and it is essential that the fertilizers be well mixed with the soil.

On soils that are naturally well drained and where surface water can not accumulate, the plowing may be done in large blocks, but where the opposite conditions are found or irrigation is practiced it may be necessary to plow the land in narrow beds. In the case of insufficient drainage it will be desirable to throw the soil into beds, leaving double furrows between the beds to carry off surplus water. Where the flooding system of irrigation is practiced the beds must be leveled and a system of ditches and ridges provided for distributing and controlling the water. Where it is merely desired to secure surface drainage the beds may be from 75 to 150 feet in width, but for irrigation purposes the beds are generally but 12 or 15 feet in width. If spring plowing is practiced the soil should be harrowed closely behind the plow in order to prevent drying out.

For cutting and pulverizing the soil there is perhaps no tool as serviceable as the disk harrow. There is a type of disk having four gangs, in two sets, one combination in front of the other and so arranged that the soil is first turned to the center and then turned outward again by means of the rear combination. This tool turns the soil twice and leaves it in a level condition. For smoothing and leveling the soil behind the plow a harrow of the type shown in figure 1 is very desirable; this tool not only levels but turns and crushes the soil at the same time.

On land that has been plowed during the autumn and requires replowing in the spring, a device of the type shown in figure 2 will answer and will do the work more rapidly than the plow. This tool is especially adapted to bedding up land that has been previously plowed.

For imparting the final smoothing touch to the soil before planting there is a device consisting of a large number of small disks set in a wooden frame (fig. 3), which does about the same work as a steel rake but in a rapid manner. A drag or float made from several pieces of scantling nailed together may be used for this purpose, or if the soil is very loose a roller should be run over it. The final leveling should be performed with a tool that will fill and obliterate all tracks or other depressions in the soil, leaving a smooth, even seedbed for either seed sowing or transplanting.

FERTILIZERS

As the onion is an intensive crop and should yield great quantities of marketable bulbs for the area planted, the grower is justified in fertilizing heavily. It would be difficult indeed to make the soil too rich for onions, provided the manures are thoroughly incorporated with the soil. A heavy application of fresh raw manure just before planting would have an injurious effect, but where the manure is well rotted and uniformly applied there is nothing to be feared.

ANIMAL MANURES

There is perhaps no fertilizer so well adapted to the production of onions as plenty of disease-free, well-composted stable manure, and the quantity and frequency of application will depend upon the nature of the land under cultivation. The Bermuda-onion growers of southwestern Texas apply as high as 20 tons of sheep and goat manure to an acre every three years. In addition to the manure, there is used 1,000 to 2,000 pounds of cottonseed meal or commercial fertilizer, and sometimes a top-dressing of nitrate of soda. This sheep and goat manure, from animals that are fed largely on cottonseed meal, is saved in the corrals in a climate where there is very little rain, and contains the essential fertilizing ingredients in very high percentages. The manure is first piled where a little water can be thrown over it, and it is composted for several months before spreading on the land. The best results from this manure are not realized until the second or even the third year after its application.

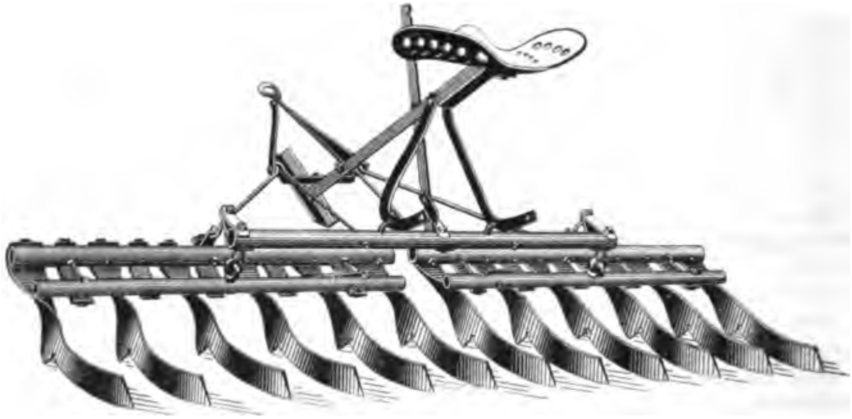

FIGURE 1.—Harrow for smoothing and leveling the soil behind the plow.

All stable manure used on onion land should be well composted before use and then spread upon the land several months before planting to onions. In the Northern States the manure may be applied during the autumn and well disked into the soil. The land can then be allowed to lie in the rough state and exposed to the action of frost during the winter, or it can be smoothed and seeded to rye, in which case it will be necessary to replow early in spring. In the Bermuda district the manure should be applied during the

spring and the land kept frequently stirred during the summer, with occasional irrigations in order to incorporate the manure and destroy weeds; the planting is not done until the autumn. Another practice in the Bermuda district is to apply fresh manure broadcast at the rate of 10 to 12 tons to the acre during the spring, then plant to corn and cultivate through the early summer, and add a top-dressing of well-rotted manure after plowing the land for onions in the autumn. This top-dressing should be well worked into the soil by means of disk harrows. Large quantities of fresh manure applied on onion land just before planting will have a tendency to produce an overgrowth of tops at the expense of the bulbs. This is especially true on irrigated lands and soils that are naturally moist.

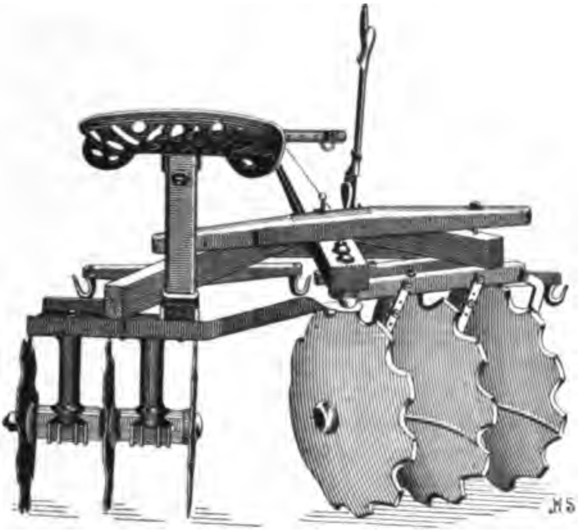

FIGURE 2.—Disk plow used for refitting land.

COMMERCIAL FERTILIZERS

A fertilizer that is suited to the growing of potatoes will serve quite well for onions, but the potash should perhaps be supplied in the form of muriate rather than of sulphate. A fertilizer adapted to the growing of onions should contain 4 to 5 percent of nitrogen, 8 to 10 percent of phosphoric acid, and 8 to 10 percent of potash.

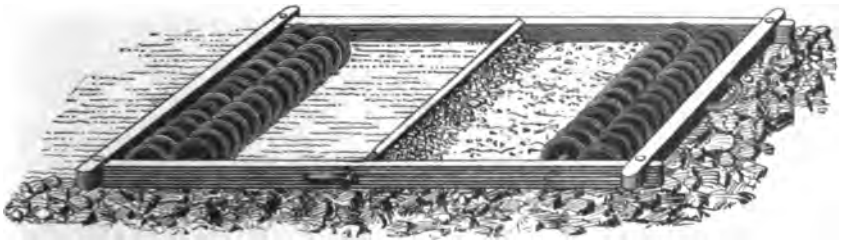

FIGURE 3.—Device used for smoothing soil before seeding.

A fertilizer of this character can be profitably applied at the rate of 1,000 pounds to the acre on most soils. Where very intensive cultivation is practiced it may be profitable to apply as much as a ton to the acre in addition to stable manure.

Commercial fertilizers should be applied shortly before sowing the seed and should be uniformly distributed and thoroughly worked into the soil. There are fertilizer distributors that scatter the fertilizer broadcast, but where an amount not exceeding 1,000 pounds of fertilizer to the acre is being used the work of distribution may be performed by means of a common grain drill having a fertilizer attachment. On a small scale the work is generally performed by hand.

Many growers follow the practice of applying only a part of the fertilizer at planting time, reserving the balance to be put on as a top-dressing at some time during the period of cultivation. This plan is especially desirable where onions are grown during the winter, as the application of highly nitrogenous fertilizers in the autumn is liable to promote a soft growth that will be injured by cold. If the fertilizer is not put on until cold weather is over, the crop may be forced without danger of injury. For this purpose only those fertilizers of a very available form will answer. Nitrate of soda is frequently used as a top-dressing during the height of the growing period.

PLANTING

Most of the onions grown in the United States are started from seed. Propagation from seed is conducted by three more or less distinct methods: (1) By sowing the seed in the rows where the crop is to grow and mature; (2) by sowing the seed in specially prepared beds and transplanting the seedlings to the open ground; and (3) by first growing sets from seed and then, after keeping them through the winter, planting them in the field to produce the crop of mature bulbs. Of these three methods the one first mentioned of seeding in the rows where the crop is to mature is the one most used on a very large scale.

SEEDING IN ROWS

In the northern onion-growing districts the seed is sown as early in the spring as the soil can be brought to the proper condition. While it is desirable to plant quite early, it never pays to sow the seed before the land is in the best possible condition. When the soil has been brought to a smooth, even surface and is fine and mellow, the seed is sown by means of a common seed drill, of which there are several makes on the market. The hand drills which sow one row at a time are extensively employed, but many of the larger growers employ a gang of drills hitched together and plant from five to seven rows at once. In heavy or moist soils the depth to cover the seed should not be more than one-half to three-fourths inch, while on loose and sandy soils the seed may be covered about an inch.

Where hand cultivation is practiced throughout, the usual distance between rows is 12 to 18 inches. Where horse culture is employed the distance between rows varies between 24 and 36 inches. The quantity of seed required to plant an acre will depend both upon the distance between rows and the purpose for which the onions are being grown. For the growing of standard market onions in rows 14 inches apart, about 4½ pounds of first-class seed will be required. With the rows 3 feet apart, but 1¼ to 1½ pounds will be necessary. Where it is

desired to produce small onions for pickling purposes, the amount of seed may be as great as 25 pounds to an acre. Good seed is essential, and if there is any doubt regarding the vitality of the seed it should be tested before planting by counting and planting 400 or 500 seeds in a window box and then determining the germination by counting the seedlings after 10 days' or 2 weeks' time. First-class seed is seldom sold at a low price and good seed at $1.50 or even $2.50 a pound may be cheaper in the end than poor seed at 50 cents. Old and inferior seeds are not only low in percentage of germination but lack the vitality necessary to produce strong, healthy plants. There are dealers who make a specialty of securing and furnishing extra-quality onion seed, and while their prices are often somewhat above the general market the seed furnished by them is preferable to ordinary seed.

Experienced growers are able by using extreme care in regulating the drills to distribute onion seed in rows where the crop is to mature so that little thinning will be necessary. Thinning is generally left until the time of the first hand weeding, when all thick bunches along the rows are thinned to a uniform stand of 8 or 10 plants to the foot. It is always well, however, to allow for considerable loss of plants, and unless the plants are so thick as to actually crowd, thinning will not be necessary.

TRANSPLANTING METHOD OF GROWING ONIONS

The transplanting process is merely a modification of the regular seeding method. The objects gained by transplanting are an earlier crop, a uniform stand, and bulbs of more regular size. Practically the entire crop of Bermuda- and Creole-type onions grown in the United States is handled in this manner. Where a small area is to be grown, the transplanting process is the ideal method, but for large acreages where labor is difficult to obtain this would not be practicable. After transplanting, the seedlings will require rain or watering, and for this reason the transplanting process is practically limited to areas where some form of irrigation is available.

In growing onions by the transplanting method the seed is sown in greenhouses, hotbeds, coldframes, or specially prepared beds at the rate of 2 to 3 pounds for each acre to be planted. Onion seedlings are now being grown in great quantities by southern plant growers and are shipped to northern onion growers. When the seedlings are grown under cover, they are given the necessary attention regarding watering and ventilation and kept growing quite rapidly until near the time for setting them in the open ground. As planting time approaches, the seedlings are "hardened" or prepared for transplanting by increased ventilation and exposure and by withholding water. When ready to transplant, the seedlings should be somewhat smaller than a lead pencil and rather stocky. The plants are lifted from the seedbed and the roots and tops both trimmed somewhat, as shown in figure 4. They are then packed neatly in shallow boxes for removal to the field where they are to be planted.

Various methods are employed for handling the plants in setting. As a rule, a line is used and the land marked to indicate the location of rows. Several methods are employed for marking the distance

between plants in the rows. A marking device much used by the Bermuda-onion growers in Texas consists of a sectional roller with the sections the same distance apart as the distance between the rows and each section provided with conical pins to form the holes in which the plants are set. The objection to the sectional roller-marker is that it cannot easily be drawn in a straight line and straight rows are essential to good cultivation.

After marking the land, the plants are dropped ahead of the planters, or they may be kept in the trays and simply removed as planted. The transplanting process consists mainly in pushing the root end of the seedling into the soil with one finger and then firming the soil about the plant. This work is very laborious and can only be performed economically by very cheap labor. A small plow, such as is generally included with the attachments of the wheel hoe (fig. 5), is often employed for opening a furrow in which to set the small onion plants. As the plants are set the soil is either drawn about them by hand, or the plow may again be used for this purpose. In the Bermuda-onion district the work of transplanting is as a rule done by contract. In transplanting, all inferior plants should be rejected, thus insuring a more nearly perfect stand and development.

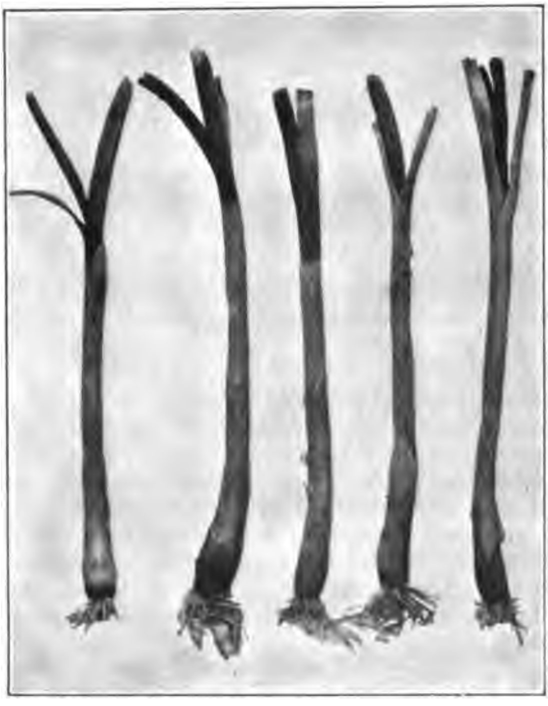
FIGURE 4.—Seedling onion plants trimmed ready for transplanting.

PROPAGATION BY SETS

The use of sets is still another modification of the regular seedling method, in which the seed is planted one year to form the sets from which to grow a crop of mature onions the following year. Like the transplanting process the use of sets is limited in its application. Onions grown from sets will ripen earlier than those from seed sown in the field and often make a good crop of bulbs when the crop grown from seed will not. In planting onion sets a furrow about 2 inches deep is opened, the sets being dropped about 3 inches apart and firmly covered. The quantity of sets required to plant an acre will depend upon their individual size and planting distances, but it is generally between 15 and 22 bushels.

CULTIVATION

The cultural requirements of the onion are frequent shallow stirring of the soil and freedom from weeds. The feeding roots of the onion run close to the surface of the soil and should not be disturbed by deep cultivation. Sometimes a heavy rain immediately after seeding will so pack the surface that the seedlings cannot break through. Under such circumstances it will be necessary to slightly break the surface by means of a steel rake or a rakelike attachment on a cultivator. As soon as the plants are up and the rows can be followed the cultivator should be started to loosen the soil, which is always more or less compacted during seeding.

HAND CULTIVATION

Where the rows are 14 inches or less apart, the work of caring for the crop is usually done by hand. For this purpose the wheel-hoe tools of various types are essential. These implements are provided with several kinds of hoes, cutters, and sweeps designed to work the soil away from the plants, to shave the surface and destroy weeds, and to stir the soil and work it back around the plants. Onions grown on muck and alluvial soils will require from 8 to 14 workings with the wheel-hoe implements; on sandy soils it will not be necessary to cultivate so frequently.

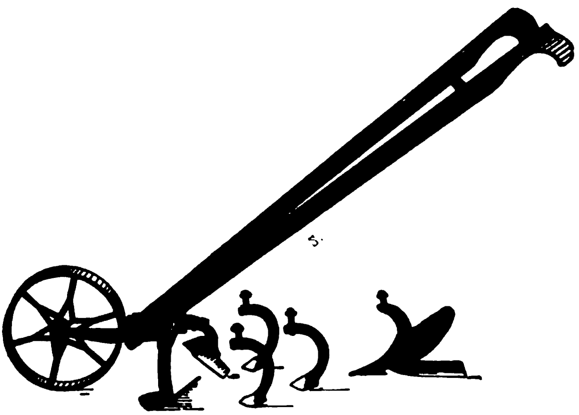

FIGURE 5.—Wheel hoe adapted to working onions.

Several types of wheel hoe are in use, but those having a single wheel and passing between the rows are most desirable. Those of the type shown in figure 5 are good. Many growers have designed special implements to suit the requirements of their soils; two of these are shown in figure 6, the one designed to cut the soil away from the row and the other to stir and work the soil back to the row. Some of the growers in the onion fields near Chicago have adopted a hoe stock consisting of a pair of light plow handles, an iron stock, and the front wheel of a bicycle. To the stock of this device may be attached almost any form of sweep or cutter, and the implement is exceptionally easy to propel. The wide distance between the handles places the implement well under the control of the operator. Figure 7 gives an idea of the general appearance of this implement.

HORSE CULTIVATION

In sections where onions are grown on a soil that is not well adapted to hand culture the rows are placed 30 to 36 inches apart and the cultivation is performed by means of horse-drawn and tractor tools. This is particularly true where onions are grown on the black waxy soils of Texas and other soils of the prairie type. As with hand culture, frequent shallow stirring of the soil is essential, the work generally being performed with one of the harrow-tooth cultivators. Those of the type shown in figure 8 are well adapted to this work. An implement known as a weeder can be used for breaking the surface before the seedlings appear; also for general cultivation by removing a tooth at the point where the rows are located.

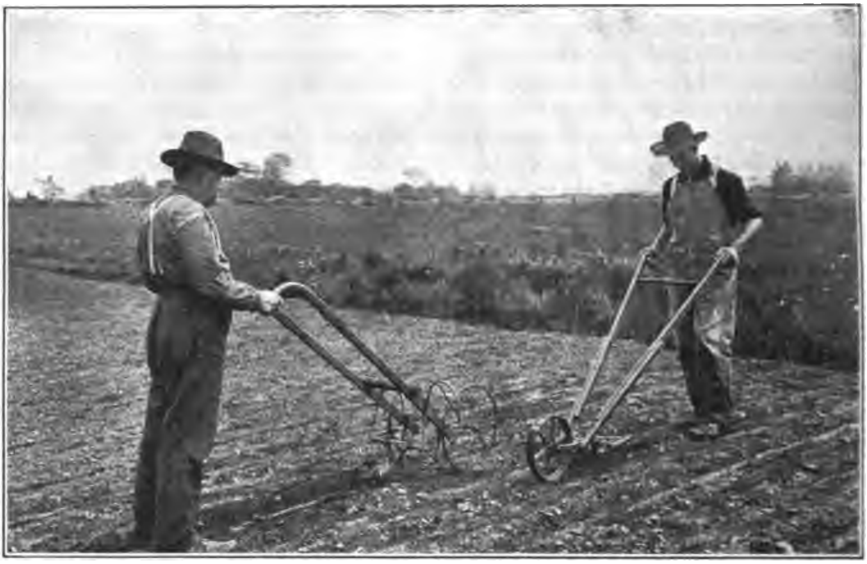
FIGURE 6.—Special wheel hoes for cultivating onions.

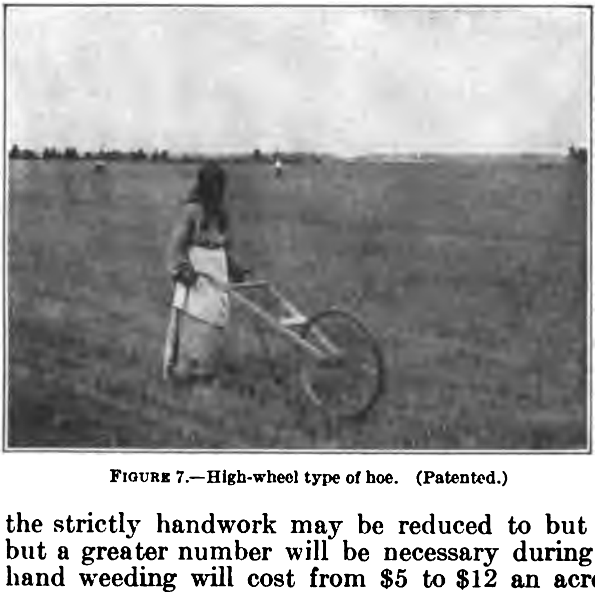
FIGURE 7.—High-wheel type of hoe. (Patented.)

HAND WEEDING

It is well-nigh impossible to produce a crop of onions without some hand weeding. During favorable seasons the strictly handwork may be reduced to but one or two weedings, but a greater number will be necessary during rainy seasons. Each hand weeding will cost from $5 to $12 an acre, according to wages paid and the number of weeds present. The work of hand weeding may be facilitated by the use of some of the small hand tools designed for the purpose. Among these tools might be mentioned the onion hoe (fig. 9), the hand weeder (fig. 10), and the thinning or weeding hook (fig. 11). Girls and boys of advanced school age are frequently employed to do the hand weeding, especially during the early summer vacation period.

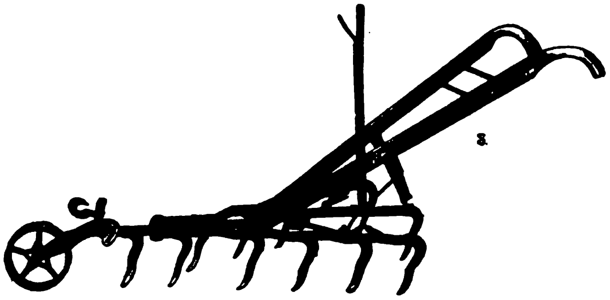

FIGURE 8.– Small-tooth horse cultivator.

IRRIGATION

Outside of the areas where irrigation methods are depended upon for the production of general crops it is not customary to use artificial watering in the growing of onions. In a few cases the land has been equipped with overhead sprinkling systems which are employed to moisten the soil after the seed is planted and also during extremely dry weather. On peat and muck soils the young seedlings are frequently lost by the dry muck blowing with the high winds of early spring. In this way a part of the field may have the soil blown off to such an extent that the plants will be left without soil about them, while other portions of the field will be covered by 1 or 2 inches of loose muck. The use of a small quantity of water sprayed over the field will sometimes prevent this shifting of the soil during a windstorm but will not prevent the accumulation of muck blown on to the plants from adjacent nonirrigated areas. Sandy soils are also subject to the action of winds to a greater or less extent, and losses may be prevented by the timely application of water over the surface. In a few instances subirrigation is employed in the growing of onions.

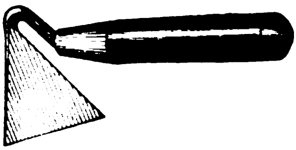

FIGURE 9.—Onion hoe.

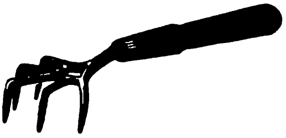

FIGURE 10.—Hand weeder.

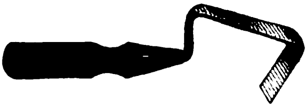

FIGURE 11.—Thinning or weeding hook.

Throughout the Southwest surface irrigation is almost universally employed. The Bermuda onions in Texas are planted mostly in comparatively level beds with dividing ridges and are flooded once each week or 10 days during the growing period. About a week before the plants are set the soil is flooded and then worked over with disk and smoothing harrows just ahead of the planters. Within a day or two after planting the land is again flooded and the surface water drawn off; this process is repeated, with alternate cultivations, as often as required. Toward the end of the growing season the water is withheld to allow the bulbs to ripen. As a rule about 10 waterings in all are required, at a cost of about $2.50 an acre for each watering, or $25 per acre altogether. Figures 12 and 13 give a good idea of the methods of applying the water.

In the principal Bermuda-onion growing districts the water for irrigation purposes is obtained only after the expenditure of thousands of dollars for pipe lines and pumping machinery. The cost of watering as given above does not include any share of the original cost for installation or water charges, but covers only the labor. In the upper San Joaquin and Coachella Valleys of California the Bermuda and Sweet Spanish onions are grown on raised beds usually holding two rows of onions and with water furrows between the beds.

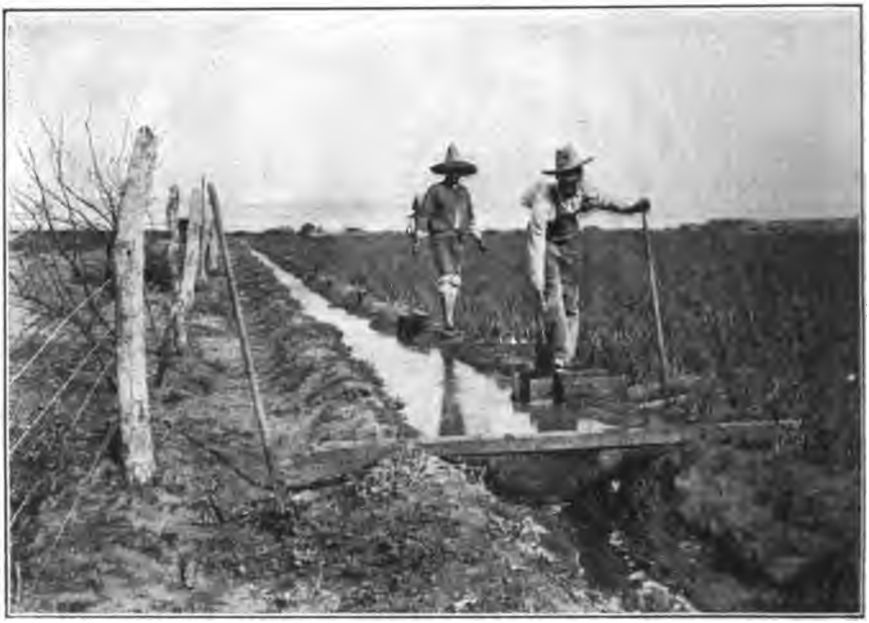

FIGURE 12.—Irrigation ditches in Bermuda-onion field in Texas.

HARVESTING AND CURING

In the northern onion districts the crop ripens and is harvested during the latter part of the summer and early autumn. As a rule the work of harvesting onions begins late in July and is practically completed and the crop housed before October. In the Southern States, where the crop is grown during the winter, the harvesting and marketing period is during the spring and is practically ended before the northern product comes upon the market.

In the North the bulbs are allowed to become as ripe as possible before they are removed from the soil. Growers prefer that the tops

ripen down and shrivel and that the outer skin of the bulbs be dry before they are pulled. Figure 14 shows a field of onions in prime condition for gathering. To the southward, where the onions are not cured so thoroughly, they are often pulled about the time that the tops begin to break and fall. The ripening process often may be hastened by rolling a very light roller or a barrel over the tops to break them down. This process is frequently spoken of as "barreling."

Where the bulbs are practically upon the surface they may be pulled by hand and thrown in windrows consisting of 8 or 10 onion rows. If the onion bulbs are considerably covered with soil it will be necessary to employ a 1-horse plow or a cultivator with a sweep attached for lifting them. In any case it will be necessary to gather them from the soil by hand. After lying in the windrows for several days and being stirred occasionally with wooden rakes, the tops are removed by cutting with ordinary sheep shears. In cases where very bright color is important, as with fancy White Globe onions, and this would be injured by exposure to the sun and rain, the bulbs are cured in long, narrow, low ricks formed by placing several rows of onions laid with the bulbs to the center and the tops to the outside to protect the bulbs. As the tops are removed the bulbs are generally placed in crates for drying. Onion-topping machines frequently are employed, the bulbs being hauled from the field to a central location and run through the topper. These machines remove the tops, grade the bulbs, and deliver them into the crates or bags. If crates are not employed for curing, the bulbs are allowed to lie in the windrows for some time, and are then either put into sacks or hauled to slat cribs,

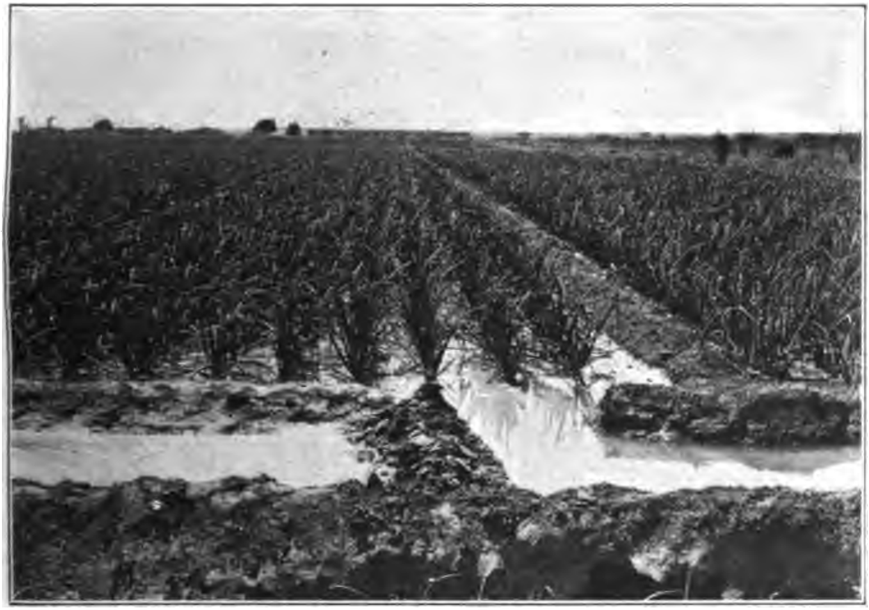

FIGURE 13.—Irrigation of Bermuda onions in Texas.

where the curing process is completed. Too long exposure to hot sunshine will injure the bulbs. Figure 15 shows a field of onions drying in windrows, with crates ready for their removal from the field.

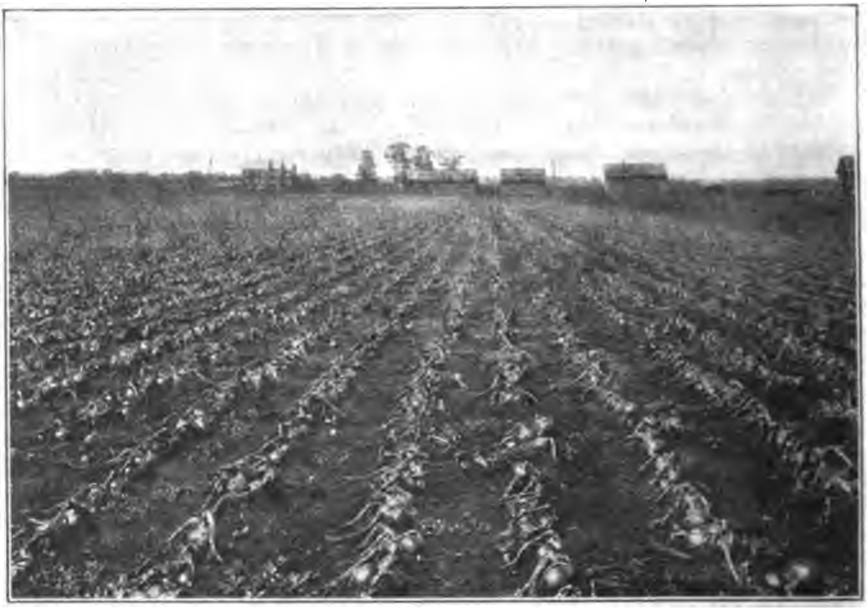

FIGURE 14.—Field of onions in condition for gathering.

After gathering into crates, the crates are either stacked in the field, hauled to a central stacking yard where they are covered with boards or canvas, or hauled to open sheds and there piled one upon the other with numerous air spaces until the onions are thoroughly cured.

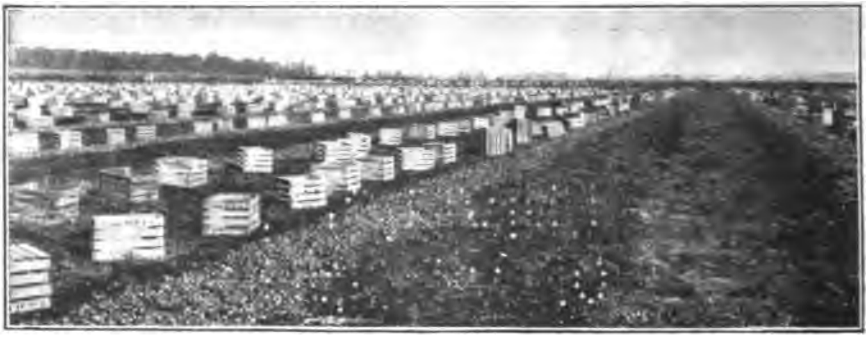

FIGURE 15.—Onions drying in windrows, showing crates used for curing and storing.

Where the bulbs are extremely dry at the time of their removal from the soil, they may be allowed to lie in the windrows for a few days only, and then sorted and cleaned in the field ready for packing and marketing. Where onions are put into sacks and afterward allowed to remain in the field, the sacks should be supported on poles laid on the ground, as shown in figure 16. In the irrigated districts of the West, where the soil can be kept dry, this precaution is not necessary.

In the Bermuda-onion districts, where only a short curing process is given to the crop, it is the practice to pack and load into the cars as soon as possible after pulling and topping. When the shipping is at its height, it is not uncommon for onions that are pulled from the soil in the morning to be in the cars and on their way to market by evening; however, a portion of the crop is given a more thorough curing process, and the entire crop would be benefited by at least two days of curing before shipment.

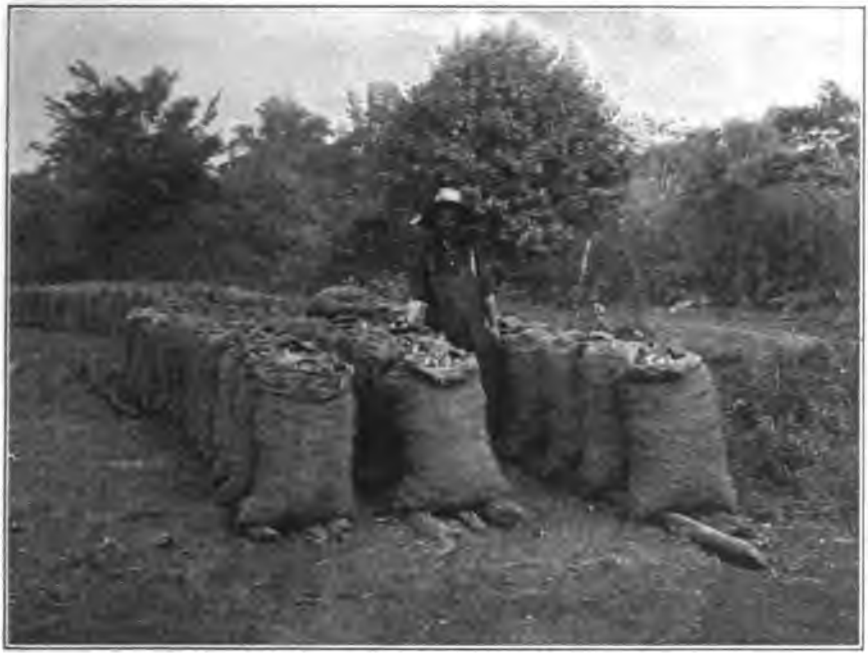

FIGURE 16.—Method of curing onions in sacks standing in the field.

STORAGE

To keep well when stored, onions must be well ripened and thoroughly cured. "Thick necks" or those that are immature, or soft, should never be placed in storage but should be sold as soon as gathered for whatever price they will bring. Good storage onions will rattle almost like blocks of wood when poured from one crate to another. In order that the bulbs may remain bright and of attractive appearance they should not be allowed to lie exposed to the weather, but should be hauled and stored in open sheds just as soon as they may safely be placed in 1-bushel crates.

After the bulbs have remained in drying sheds or cribs for 4 or 5 weeks they will be ready for screening and removal to the storehouse. In handling onions it is the rule to pass them over a screen each time they are moved, as in this way the loose skins are removed and any soft or decaying bulbs may be sorted out. When bags are used for drying in the field, the onions are screened, and the bags refilled for hauling to the storage house.

The essentials for the successful storage of onions are suitable containers, plenty of ventilation, a comparatively low temperature, dryness, and safety from actual freezing. Any building wherein the above conditions may be secured will answer, but houses of the type shown in figure 17, which are built especially for the purpose, are most satisfactory.

The construction of the storage house should be double throughout, with plenty of felt or paper lining. Both top and bottom ventilation should be provided, and the ventilator openings should have doors that may be closed to control the temperature. The floors are constructed of narrow planks with half-inch spaces between the planks for the passage of air. Bottom ventilation is frequently secured by means of drain pipes built into the foundation at the surface of the ground. These pipes are carried some distance toward the center of the house and discharge the cool air at a point where it is most needed.

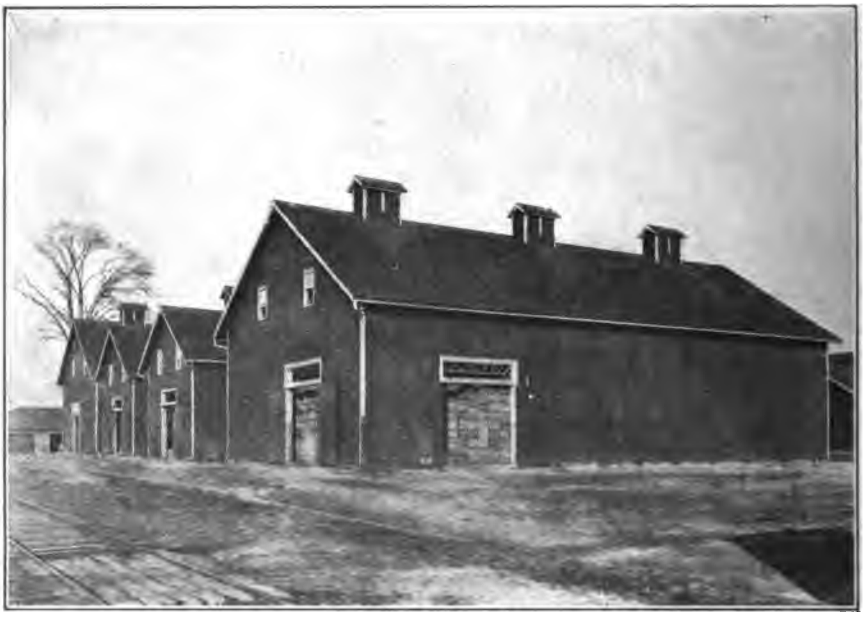

FIGURE 17.—Onion storehouses.

The temperature of the storage house should be carried as low as possible without actual freezing. During extremely cold weather the ventilator openings and doors should be kept closed to keep out cold air, and after the onions have become thoroughly chilled the house should be kept closed in order to hold the temperature down and prevent the entrance of moisture during warm or rainy periods. Damp, foggy weather is injurious to onions, especially if it follows a period of cold and will cause the bulbs to become covered with moisture if the outside air is admitted. A little artificial heat from a stove or radiator may be required during excessively cold weather, but so long as the temperature in the house does not fall below 32° F. there will be no danger of injury. A temperature of 36° to 38° will give good results.

The best method of storing onions is in standard-size slat crates 20 inches long, 16 inches wide, and 14 inches deep, outside measurements. The material for the sides and bottom is about three-eighths inch thick and 2¼ inches wide, four pieces being used to form a side. The corners are reinforced on the inside by means of 3-cornered pieces of oak, to which the slats are nailed. These dimensions provide crates that are interchangeable, the width of five being equal to the length of four. The crates will also nest together when empty, with one inside of two turned together. The full crates are stacked in the storehouse with 1 by 3 inch strips between them to allow for the circulation of air, as shown in figure 18.

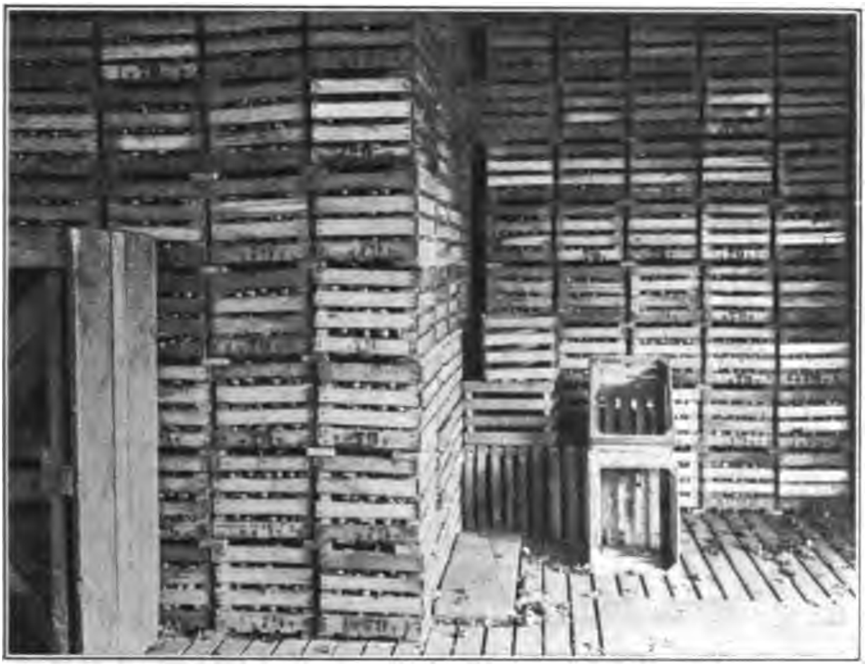

FIGURE 18.—Inside of storage house, showing method of stacking crates.

Onions are sometimes stored in slat bins holding 100 to 300 bushels each. Bags are also used to some extent, but neither bags nor bins are as satisfactory as the crates, on account of the difficulty in providing the necessary ventilation and change of air through the onions. Bulbs stored in bags or bins must be more thoroughly cured than those stored in crates. There are single large storehouses in use that will accommodate 50,000 to 60,000 bushels of onions when stored in crates.

MARKETING [1]

Large quantities of onions are sold and shipped direct from the fields where they are grown. A part of the crop is held in temporary storage until late autumn or early winter. During recent years the winter storage of onions has become of great importance, and the finest stock is held for late-winter deliveries. The Bermuda crop from the southwestern part of the country comes on the market during April and May, so that most of the storage onions are disposed of before that time.

In marketing onions the first essential is to properly grade and clean the bulbs, in order that they may present an attractive appearance when offered for sale. Ordinarily the bulbs are separated into three grades—primes, seconds, and picklers. The primes include all of those 1¼ inches in diameter and larger, and the seconds consist of those from three-quarters of an inch to 1¼ inches in diameter, while all those that will pass through a ¾-inch screen are sold for pickling purposes. The grading is generally done in the field during the cleaning process, but as onions shrink considerably while in storage it is necessary to regrade before placing upon the market. For cleaning the pickling onions an ordinary fanning mill is employed, special screens being provided for the purpose.

Onions are placed upon the market in 1-bushel crates, bags, 1-bushel hampers and baskets, and occasionally in bulk. The open-mesh bags, made in different sizes and colors, are undoubtedly the most attractive package in use for marketing onions. These bags hold from 12 to 100 pounds. Onions are sometimes shipped loose in cars and shoveled into barrels or bags at their destination.

The legal weight of dry onions is generally considered 56 pounds to the standard bushel, although this varies somewhat in different States.

COMMERCIAL VARIETIES

For trade purposes onions are divided into two large classes—"strong" onions and "mild" onions. Each of these classes may again be divided into four color classes—white, yellow, brown, and red—and each of these color classes into those which will produce bulbs when the days are short (12 hours or shorter) and those which require long days (13 hours or longer) for bulb formation.

The short-day varieties are the ones adapted to the South or other regions of the country where they may be grown through the winter, and since they form bulbs when the days are relatively short, they mature before the long-day varieties. The most important mild-fleshed, short-day varieties are Yellow Bermuda (pale yellow), Crystal Wax (white), and Early Grano (pale yellow). Red Creole and White Creole are the common "strong" short-day varieties and, unlike Yellow Bermudas and Crystal Wax, are excellent storage varieties. None of these varieties are recommended for culture in the North, where seed is sown in the field in the spring, as they mature so quickly that the bulbs are usually very small.

Sweet Spanish, or Valencia, is the mildest flavored of long-day varieties, a fair storage onion of large size, yellow skin, and late maturity, and somewhat resistant to thrips.

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[1] For detailed information on the marketing of onions, see U. S. Department of Agriculture Technical Bulletin No. 555, Marketing Onions.

In the Mountain States of the West the Sweet Spanish is by far the most important variety of onion grown. This variety seems to be especially well adapted to the high plateau region of the West; Idaho, Utah, and Colorado being the most important producing States.

The increase in acreage of the Sweet Spanish type of onion is the most significant change that has occurred in the onion industry of the United States during the last 20 years. Its mildness and ability to produce high yields no doubt help to explain its great popularity.

Seeding is usually done directly in the field. In the West, seed is usually sown on raised beds to facilitate irrigation. Seeding is done as a rule as soon as the ground can be worked in the early spring at the rate of 3 to 3½ pounds of seed to the acre.

Considerable improvement work has been done on the Sweet Spanish type during recent years by various seedsmen and agricultural experiment stations, and strains are now available that keep fairly well in storage. In certain districts this type of onion is stored at a higher temperature (45°–50° F.) than has been the custom for the ordinary storage types, as the bulbs can be kept somewhat drier.

The strong, long-day varieties are mainly grown in the major main-crop or storage-crop sections of the northern part of the United States. These varieties differ in season of maturity, shape, and color as follows: Early Yellow Globe (early, round), Ebenezer or Japanese (early, flattened, yellow), Yellow Globe Danvers and Ohio or Michigan Yellow Globe (midseason, round), Stockton Yellow Globe (California midseason, round), Southport Yellow Globe (late, round oval), Red Wethersfield (midseason, flat round), Southport Red Globe (late, round, oval), White Portugal (midseason, flat round), Southport White Globe (late, round oval), and Australian Brown (late, round, small).

In the selection of varieties for any particular locality the soil and climatic conditions and market requirements should both be considered. Those adapted to the muck soils are the yellow and red sorts. For alluvial and prairie soils the red and brown varieties are to be preferred while all kinds do well on the sandy loams and light soils. A cleaner, better grade of white onions can generally be produced on light or sandy soils than on muck or clay loams. Those of the Bermuda, Spanish, and Egyptian types flourish on the deep, rich alluvial soils of the river bottoms and delta regions.

Certain of our markets show a decided preference for onions belonging to a particular type. The red and brown varieties find ready sale on the markets of the Middle West, while onions of the yellow and white varieties are preferred in the eastern cities. Onions will withstand long-distance shipment, those of the mild type being generally more subject to injury than the strong sorts. Some of the white varieties also have a thin skin and are easily injured. It should be the aim of every grower to employ varieties that will withstand handling and at the same time find ready sale on the market.

The top or tree onion, which reproduces by means of small bulblets formed on the top of the seedstalk, is extensively used in the production of early-spring bunching onions.

The multiplier or potato onion reproduces by a division of the bulbs. In growing this variety it is necessary to plant large bulbs to produce sets for the next year's planting and small bulbs or sets for the crop of large onions. The bulbs of this variety may remain in the soil year after year and are desirable for use early in spring.

PRODUCTION OF BERMUDA ONIONS

Bermuda onions are now an important commercial crop in Texas and California, with small plantings in a number of the Southern States. The Bermuda onion fields of Texas are located around Laredo and other points in or near the Rio Grande Valley. In California they are grown chiefly in the Coachella and upper San Joaquin Valleys.

SOILS AND CLIMATE ADAPTED TO THE BERMUDA ONION

Soils of a silty or alluvial nature are suited to the production of Bermuda onions, and those containing considerable sand are most desirable. As already noted in referring to fertilizers for onions, the Bermuda requires a very rich soil for the best results, and this can only be obtained by first selecting a good soil and then fertilizing heavily. The Bermuda onion as grown in this country is a winter crop; therefore, mild climatic conditions are required. While the plants would withstand considerable freezing, their growth is seriously checked by cold weather, and the crop will not mature in time for the early market if grown to the northward.

CULTURAL METHODS

The cultural methods employed in the growing of Bermuda onions are essentially the same as those for ordinary onions. As the greater portion of the crop is grown in a region which has no regular rainfall, irrigation methods are employed almost universally. The greater part of the crop is grown by the transplanting process and a great amount of hand labor is required. The seeds are sown in specially prepared outdoor beds from the middle of September to the middle of October, and the seedlings are transplanted to the field November 20 to January 10, or even later. About 2 pounds of seed are required for each acre to be planted; this will allow for discarding all the weaker plants. The plants are allowed to remain in the seedbed until they are from three-sixteenths to one-fourth inch in diameter before they are transplanted. As the seedlings are lifted the greater portion of both the small roots and the tops is trimmed off in order that they may be transplanted more readily. (Fig. 4.)

HARVESTING AND MARKETING

Bermuda onions are harvested as early as possible, generally before the tops have become fully ripened. For removing the bulbs from the ground a 1-horse plow, a potato digger, or a cultivator with a cutter wing attached is employed. The bulbs are then separated from the soil by hand, the tops cut off with shears, and the onions thrown in windrows or crates to dry in practically the same manner as for the regular-crop onions in the North. After the bulbs have become thoroughly dry on the surface they are either placed directly in the crates or open-mesh bags for shipment or are carried to a packing shed to be graded and packed for market.

During the early days of the Bermuda-onion industry the crop was shipped largely in bags, but it was soon found that the bulbs were too perishable for this method of handling. At present the greater portion of the crop is sent to market in folding slat crates that are about 20 inches long, 12 inches wide, and 12 inches high.

These crates hold approximately 50 pounds of onions and weigh 56 or 57 pounds when filled. The cost of these crates is about $20 a hundred, but they add enough to the attractiveness and carrying qualities of the onions to make their use profitable.

YIELD OF BERMUDA ONIONS AND PRICES OBTAINED

Phenomenal yields of 34,000 and 35,000 pounds of Bermuda onions are frequently made on an acre of land, but this is far above the general average, which is in the neighborhood of 10,000 or 12,000 pounds to the acre. Many fields, especially when planted for the first time, do not yield as much as 10,000 pounds to the acre. On land that has been heavily manured and planted to onions for several years the yield averages about 16,000 pounds.

The best Bermuda-onion farms are valued at $300 to $500 an acre. In order to prove profitable, the growing of Bermuda onions should be conducted on a comparatively large scale. The necessary land and irrigation facilities will require the initial outlay of from $10,000 to $30,000, and the running expenses are quite heavy. The markets are now pretty well supplied with Bermuda onions, and persons who desire to engage in their production are advised to investigate every phase of the industry before embarking too heavily in it. The expansion of the Bermuda-onion industry is limited by the facts that a large supply of bulbs can be grown on a comparatively small area, that the distance to market is great, that the product is perishable, and that the markets will consume only a limited quantity at the prices at which the crop can be sold with profit.

GREEN ONIONS FOR BUNCHING

Another phase of onion culture that is of considerable importance in certain localities is the production of young bunching onions for the early spring trade. In several sections along the South Atlantic coast the growing of this class of onions is quite an enterprise. Many persons who are engaged in other lines of work follow the practice of growing a small area of bunching onions as a side issue.

The varieties known as multipliers and top onions are generally employed for this purpose; however, bunching onions are sometimes grown from ordinary sets, from inferior and damaged large onions, and from seed.

CULTURAL METHODS

For growing bunching onions the bulbs or sets are planted during the autumn either in beds or in rows 12 or 14 inches apart with the bulbs quite close in the rows. The bulbs will start growing within a short time and make more or less growth during the winter. As soon as the weather becomes warm during the first months of spring the onions make a rapid growth and are ready for marketing about the time peach trees begin to bloom.

The land upon which these onions are grown should be rich and mellow, but very little actual cultivation will be required. Where the winters are severe it may be necessary to provide slight protection, either a little straw, loose manure, leaves, pine straw, or corn fodder that has been run through a shredder. If the onion beds are protected on the windward sides by means of a windbreak consisting of a grove of pine trees, a fence of boards, pine boughs, or corn fodder, the crop will be ready for marketing a little earlier than if left exposed. Multiplier onions not gathered for marketing are allowed to remain to form the bulbs for planting the following season.

MARKETING

In marketing this class of onions the young scallions are pulled, the roots trimmed, and the outside peeled off, leaving the stem white and clean. They are then tied in small bunches by means of soft white string, the tops trimmed slightly, and the bunches packed in crates or baskets for shipment or for sale on the local market. This phase of the onion industry is limited to small plantings and is well suited to the general market garden.

During the spring and early summer large quantities of ordinary young onions are pulled when the bulb is about the size of a 50-cent piece, the roots and tops are trimmed, and they are then bunched and sold for stewing purposes. So far as known, this class of onions is not shipped to any great extent, but is sold mainly on local markets.

GARLIC AND LEEKS

Garlic is closely allied to the onion, but will remain in the ground from one year to another in a mild climate if undisturbed. Garlic is planted by setting the small bulbs, or cloves, in either the autumn or early spring The culture is practically the same as for the onion.

The leek also belongs to the same class as does the onion, but requires somewhat different treatment. The seed is usually sown in beds and the plants transplanted about 4 inches apart in the row. The plants of the leek are given about the same cultivation as onions, except that after they have attained almost full size the soil is drawn around them to a height of 6 or 8 inches to blanch the fleshy stem. The leek does not form a true bulb like the onion, but the stem is uniformly thick throughout. Leeks are marketed in bunches, like young onions, and they may be stored in cellars for winter use.

DISEASES OF THE ONION

The onion crop of the United States is by no means free from disease. For information regarding such diseases and measures of control, the reader is referred to Farmers' Bulletin 1060, Onion Diseases and Their Control, published by the United States Department of Agriculture, Washington, D. C.

ONION INSECTS AND THEIR CONTROL

In the United States the onion crop has only two serious insect pests. Of these, the onion thrips (*Thrips tabaci* Lind), because of its distribution over the entire country, is probably the most injurious. It is nearly always present on onions, and under favorable conditions it may increase to such an extent as to become very destructive. The onion thrips is a very small louselike insect, pale brown in color, and usually is first noticed because of the minute whitish spots which it leaves on the tips of the foliage after rasping away part of the leaf surface in feeding. The eggs are laid just beneath the surface of the leaf, and the insects, in both the mature and immature forms, feed on the surface from the sheath to the tip. In serious infestations the tops of the onions become grayish white, afterwards turning brown and dying. At such times the leaves, if examined, may be seen to be covered with thrips.

The onion thrips is particularly injurious in the South, and in the Texas Bermuda-onion district it is a constant menace to the crop. It is particularly likely to injure plantings which follow or are adjacent to such early crops as cabbage, from which the thrips migrate in great numbers at harvest time. A vigorous, strongly growing onion crop may grow away from thrips injury, but if for any reason growth becomes badly checked, damage is almost sure to result.

Onion breeding work now under way has for its object the production of strains of onions that have round and widely separated leaves with very little sheath under which the thrips may hide or be protected from sprays or dusts applied for their control.

Thrips may be fairly well controlled by spraying with nicotine at the rate of three-fourths of a pint of a 40-percent solution to 50 gallons of water in which 4 pounds of soap has been dissolved. Use a high-pressure sprayer and hold the nozzle close to the plants, as thrips often feed and remain protected in the leaf sheaths and creases. Clean up weed patches near the onion fields and rake together and burn the onion tops as soon as the crop is harvested. The grower should examine his onion plantings from time to time in order to detect the early stages of the infestation. It is easier to keep an infestation down by early treatments than to control a heavy infestation.

In the northern part of the United States the onion maggot (*Hylemyia antiqua* Meig.) often becomes very destructive, especially to small seedling onions. This pest is a white, footless maggot, the larva or young of a fly much resembling the common housefly, and is about three-eighths of an inch in length when full grown. The eggs are laid by the fly early in the spring, and are placed, in the case of seedling onions, on the ground near the plant, or in the sheaths of the leaves near the ground. On hatching, the young maggot burrows into the plant and bores through the stem and bulb, easily killing small seedlings. After killing one plant it proceeds to the next, thus causing many skips in the row. When larger plants are attacked, several larvae may be found in the bulb.

A remedy that has been used successfully in some sections consists of treating the soil about the plants with a bordeaux-oil emulsion. The emulsion is best applied to the onion rows by means of a sprayer, the material being directed to the base of the plants. Enough of the material should be applied to moisten the soil at the base of the plants. The bordeaux-oil emulsion may be prepared by adding 1½ gallons of oil emulsion, suitable for use against orchard scale insects, to 48½ gallons of 4-4-50 bordeaux mixture. Apply five times at weekly intervals, beginning when the young plants are about an inch high. An effective treatment requires about 115 gallons of the spray per acre.

Cutworms are sometimes troublesome, but are easily controlled by the bran mash and arsenic bait, scattered thinly wherever the young seedlings have been found to be cut off.[2]

PRESENT STATUS OF THE ONION INDUSTRY

Because of variations in the cost of labor, tools, fertilizers, seed, and other materials and the many factors involved in the production of an onion crop it is impossible to give definite cost and profit figures. The average yield of onions is around 290 bushels to the acre, but yields of 400 to 600 bushels are not uncommon. The price of onions is extremely variable from one year to another, but on the whole the crop has proved profitable to the growers when taken on an average for a period of years.

In some sections onions are grown in rows 3 feet apart and given horse cultivation, thus reducing the yield to about 150 bushels on an acre and cutting down production costs in proportion. This method of growing onions is especially adapted for use on low-priced land and where hand labor is scarce.

Both the supply and demand for onions are increasing and at present bear about an equal relation to each other. Some years the supply falls a little short and the prices go somewhat higher, with the result that larger quantities are imported. The following season the plantings are generally heavier, the market may be a little slow, and the result will be low prices, and a great many people will discontinue the growing of onions or reduce their acreage.

Prices of onions, especially the Texas-grown Bermuda onions, are greatly influenced by importations of Egyptian onions which appear on our markets about the same time of the year that the Bermuda onions are being marketed. The ease with which both the Egyptian and the Spanish onions can be delivered to our eastern markets as compared with the long freight haul from southwestern Texas or Pacific Coast States renders the position of the American grower of Bermuda and other mild onions more or less hazardous. Despite this condition, however, both the Bermuda and the Spanish onion industries have become well established in the United States.

Recently the production of the large Sweet Spanish onion has become well established in a number of the Western States, and with the present tariff rate in effect on imported Spanish and other onions American growers are in position, under normal crop conditions, to fully supply the principal markets of the United States. American growers of the Sweet Spanish and Bermuda onions are no longer dependent upon imported seed, as an adequate supply is now being produced by the California and other western seed growers.

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[2] For further information write to the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

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FARMERS' BULLETIN 355.

A SUCCESSFUL POULTRY AND DAIRY FARM.

BY

W. J. SPILLMAN,

Agriculturist in Charge of the Office of Farm Management,
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 27, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "A Successful Poultry and Dairy Farm." This manuscript was prepared by Prof. W. J. Spillman, Agriculturist in Charge of the Office of Farm Management of this Bureau, who for several years past has made a careful study of the system and methods in vogue on this farm.

The farm described in this manuscript is of peculiar interest. It was hewn out of the timber by the owner and his family and farmed by them for eighteen years practically without outside help. It produces large crops; it is properly diversified in that it has two principal industries and one minor one; it is eminently adapted to the conditions of local environment; it is highly profitable; of the three boys and three girls raised on the farm those who have desired it have obtained a college education or are doing so. The owners of this farm are recognized as high authorities in agricultural matters by those who are acquainted with their work. They take a leading part in the farmers' institute work of the State in which they reside and are well known as contributors to agricultural papers. It is believed that this description of their methods and results will be of great value to all farmers in this country.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction........ 5
History of the farm and its owner........ 6
Hours of labor........ 8
Drainage........ 9
The cropping system........ 9
The silo and the silage crops........ 11
The handling of manure........ 12
The dairy herd and its management........ 12
  System of feeding dairy cows........ 15
    Winter feeding........ 15
    Summer feeding........ 15
    Soiling crops........ 15
  Manner of harvesting certain crops........ 17
  Daily routine for cows in summer........ 17
  Freshening and drying cows........ 17
  Care of the bulls........ 18
  Rearing the calves........ 18
  Disposing of the products of the dairy........ 19
Hogs........ 20
  Management of pigs........ 20
Poultry........ 21
  Poultry houses........ 21
  Vermin........ 23
  Incubation........ 25
  Percentage of hatch........ 26
  The brooders........ 26
  Feeding the young chickens........ 28
  Males and culls........ 29
  Management of males selected as breeders........ 30
  Care and management of pullets........ 30
  Selecting layers and breeders........ 31
  Age of hens........ 32
  Care and management of laying hens........ 34
  Broody hens........ 35
  Feed of laying and breeding hens........ 35
  Cleaning day........ 37
  Management of breeding hens........ 37
  Selecting the males........ 38
  Poultry products marketed........ 39
  Income from poultry........ 40
Work stock........ 40
Concluding remarks........ 40

ILLUSTRATIONS.

Page.
FIG. 1. Calf stanchions.. 19
2. Plan of poultry building and yards.................................... 22
3. End view of feed room in poultry house............................ 23
4. Front view of a single compartment of the poultry house............ 23
5. Ground plan of a compartment of poultry house...................... 24
6. Front view of perches, nest boxes, etc................................ 24
7. Cross section of poultry pen, showing method of supporting nests and perches.. 25

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

B. P. I.—417.

A SUCCESSFUL POULTRY AND DAIRY FARM.

INTRODUCTION.

A strong tide is setting in from the city to the country. Not only is it becoming fashionable among wealthy people to own country homes, where they either farm or play at farming, but city wage-earners and substantial salaried employees are looking more and more to the farm as a relief from the grinding toil of the city and the uncertainty of salaried employment. The following letter is typical of many received by the Department of Agriculture:

> I am an employee in a large manufacturing establishment. My wife, mother, and sister are dependent on my income, which is $1,000 a year. I have saved $2,000. I do not know what time some relative of a high official of the company may need my place. I desire to own a farm and live on it, so that I may feel the sense of proprietorship. I am offered 80 acres of land for $2,000. I am thinking of offering $1,000 cash and a like amount on time for this farm, so that I may have capital for starting in business. Do you think I can safely make the change?

The Bureau of Plant Industry is trying to get in a position to answer questions like this. Farming is a complex business. The successful farmer must be a good manager. This means that he must know what to do and how to do it, and must be able to do things at the time they should be done. He should have some knowledge of physics, mechanics, chemistry, physiology, and engineering. He must know something of the breeds of live stock and of the principles involved in feeding and breeding them. He must know something of soils, and most of this knowledge of the soil must come from experience with the particular soil he farms. No amount of knowledge of these things gleaned from books will completely take the place of experience. No man can begin farming without previous experience and be successful from the start. Yet some of the most successful farmers in this country began farming in middle life. Their success has been due to persistent effort, indomitable energy, patience, and a realization of their lack of knowledge which led them to seek information from every possible source. The first few years were full of discouragement. Later, many such men have won enviable reputations as farmers.

The present article is the story of a professional man whose longing for the freedom of country life led him at the age of 36 to abandon the city for the farm. Unfortunately the record of his early struggles is very incomplete. That these were severe is attested by the fact that the owner and his family, with a little hired labor, have cleared 76 acres of heavily timbered land, built a comfortable home, with substantial barn, dairy house, silo, and poultry houses, and have developed under trying conditions one of the best-paying farms in the country. In 1906 the gross income of this farm was about $5,000; it is considerably larger now.

The farm referred to is that of Mr. H. L. Blanchard, of Jefferson County, Wash. It lies on the west side of Puget Sound, at the base of the Olympic Mountains. The products of the farm are butter, eggs, poultry, and a small quantity of fresh pork. These are carried to market 12 miles over a fairly good macadam road, by team, once a week. So careful is the owner of this farm of the market he has made that he has not once failed to deliver his products on his regular market day during the past twelve years.

Since this farm has been brought to its present profitable state by the joint efforts of every member of the household, it is proper to say that when the family moved to the farm in 1887 it consisted of man and wife, three boys, and three girls, the oldest child being a boy of 13. The only labor ever hired on this farm before the first son entered an agricultural college was a wood chopper for less than three months in 1886 to help do the first clearing, two carpenters for two weeks in building the house in 1887, and other assistants for miscellaneous pieces of work costing not over $100 during the entire eighteen years up to the fall of 1905. The father and the three sons have done the farm work, milked the cows, and made the butter. The household duties have been systematically discharged by the mother and daughters, and for several years the mother and one of the daughters have run most of the poultry business, another daughter has reared the calves, while the third daughter has kept the books of the establishment.

HISTORY OF THE FARM AND ITS OWNER.

Mr. Blanchard was reared on a dairy farm in western New York. He was educated for the law and followed that profession for seven years. While practicing law he organized an iron company and spent the next seven years in connection with its business. This brought him again in contact with outdoor life, which he enjoyed and which gave him better health. The iron business did not prove satisfactory because of the excessive cost of the product, so that in 1886 he determined to buy a farm and devote his life to farming. Accordingly he bought entirely on credit 80 acres of land, all heavily timbered, for which he contracted to pay $33 an acre.

He began clearing the land at once (June, 1886). During the summer of 1886 and the following fall and winter, with the aid of his 12-year-old son and a hired chopper, who worked less than three months, he delivered 200,000 board feet of timber to a near-by sawmill. The sum received for this timber was sufficient to pay the chopper and to buy lumber for a home and barn. The house was built in 1887; as soon as it was ready the family moved to the farm. At this time the obligations of the family amounted to $3,000.

The first important task after the family was established on the farm was the clearing of the land. Unfortunately, few who read this realize what clearing heavily timbered land in western Washington means. The owner estimates that had he hired all the labor for this it would have cost $70 an acre for the bottom land and not less than $150 an acre for the upland, including the removal of stumps.[a] Twenty acres of the bottom land was so filled with fallen logs sunken in the soft muck soil that it could be used for pasture only for many years after clearing. Part of this 20 acres was put into cultivated crops for the first time in 1906.

Clearing went forward as time could be found for it. The first planting, consisting of 2 acres, was made in 1887. In 1888, 10 acres more were put in cultivation; in 1889 another 10 acres. In 1890, 15 additional acres were cleared sufficiently to be seeded to pasture grasses, and a like area was seeded for pasture the following year.

Much of this land was so wet as to require underdrainage, and the winter months were largely spent in putting in the necessary drains. These were made of cedar lumber obtained in the clearing operations.

In 1887 the owner of the new farm gave up his connection with the iron company. At that time the farm would not support the family. A good team and wagon enabled him to earn something by hauling timber and lumber for farmers who were clearing and building. He did such work for others as a means of supplying his family with the necessaries and comforts of life. From the first he kept 1 or 2 cows, and in 1890 he had 6 or 7, descended from the old family cow and two others he had bought. The year before this he sold his first butter, put up in hand-made rolls and taken to market in a bucket. A piece of good fortune the second year made life comparatively easy the succeeding winter, for in the spring he planted 5 acres of potatoes, which made a good crop. As this was a famine year for potatoes, he was able to sell his entire crop at 2½ to 3 cents a pound. Potatoes were planted again the next year, but the price was low and little profit was made. Finding a ready sale at fair prices for the small quantity of butter made the third year, he sold more the next year, and thereafter developed the dairy business as fast as conditions would permit. The neighboring farmers were astonished when he attempted to keep 7 cows on so small a farm; they said it could not be done. Nevertheless, in 1899 he had 36 cows in milk, raising all the roughage for these and for the necessary bulls, young stock, and work horses, besides some grain for the poultry. A cream separator was installed in 1891. The same year one of the daughters embarked in the poultry business. Three years later this business had grown to such proportions that the mother's assistance was necessary. At the present time (1908) the mother and daughter care for about 500 laying hens, while the head of the household has another flock of 200 for which he is individually responsible.

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[a] Investigations now in progress by the Department of Agriculture show conclusively that these estimates are conservative.

In the early days chickens, pigs, and cows were all kept in the same stable, the chickens being kept in a double deck over the pigsty. At the present time the equipment for managing poultry is hardly surpassed on any poultry farm in the country. As the older boys go off to college, the poultry business is gradually replacing the dairy, the work being lighter and the remuneration greater.

HOURS OF LABOR.

The hours of labor on the Blanchard farm are as follows:

5 to 7 a. m.—Feeding, milking, and separating the milk.
7 to 8 a. m.—Breakfast.
8 to 9.30 a. m.—Stable work, the cows being turned out to water while the stables are cleaned.
9.30 a. m. to 12 m.—General farm work.
12 m. to 1 p. m.—Dinner.
1 to 4 p. m.—General farm work.
4 to 6 p. m.—Chores, including milking.

Aside from the management of the poultry, the work of this farm is done by 3 men, including the owner, who in addition takes the entire care of 200 hens. At the present time the dairy herd consists of 33 cows. Since 1905 some hired labor has been employed, the wages paid being $30 to $40 a month with board and lodging.

The wages paid and the hours of labor may seem to compare unfavorably with those of corresponding occupations in the city; but is this really the case? It will be noticed that the working day is broken up into several periods during which different kinds of labor are done. The longest continuous period at the same employment is three hours. Although the total period of labor is eleven hours a day, it is so divided that the work does not become monotonous and is therefore not drudgery. Again, $30 or $40 a month, with excellent board and good lodging, is better wages than $50 or $60 a month in the city, where board and lodging, usually of a very inferior kind, must be paid for out of the wages received. With such employment the laborer, if he is industrious and frugal, may lay by capital and ultimately become a proprietor himself. Few city employees, even those holding the more desirable clerkships in the leading stores, can save as much as they could as laborers on the better class of farms, nor can they live as well.

DRAINAGE.

As previously stated, a considerable portion of this farm consists of low-lying, more or less peaty soil. A fair-sized stream runs through this and gives some trouble by overflowing occasionally during the winter—the period of the year when most of the rain falls in all sections west of the Rocky Mountains. Perhaps 50 acres of the land on this farm require drainage. The stream bed is only slightly depressed below the general level of this 50 acres, so that drainage is more or less of a problem.

In the soft, peaty soil the drains are put in at distances ranging from 30 feet in the wettest places to 80 feet in the drier parts. The depth of the drains varies from 2½ to 3½ feet, according to the fall obtainable, the greater depth being preferable, because the settling of the loose soil soon exposes shallow drains. Formerly the drains were made as follows: A ditch was dug 2 feet wide and as deep as the fall would permit. Then two cedar timbers 5 inches square were placed at the sides in the bottom. These were covered by 2-inch cedar planks, 2 feet long, laid crosswise, and the ditch was then filled up with earth. As long as timber was abundant this method was satisfactory. Much of the excavating could be done by means of a plow, and the value of the labor expended in putting in these drains was estimated at 60 cents to $1 a rod. Now that lumber for the underdraining must be bought, the plans for the work are to be changed. Earthen tile would soon become displaced in this soft earth, so that drains are to be made of 1 by 6 inch cedar boards, nailed together so as to make a long, square box. Two extra short boards are nailed on the ends of each box, so as to project 6 inches. When two of these boxes are placed end to end the short pieces nailed on the outside hold the ends in place. The ditches are dug only wide enough to receive the boxes.

THE CROPPING SYSTEM.

Of the total area of 80 acres, 4 acres of gravelly upland remain uncleared. Of the 76 acres from which the timber has been removed, only about 66 are in the farm proper, the remainder being taken up by roads, a stream, barn lots, chicken runs, a garden, an orchard, the dooryard, and a piece of hilly, gravelly soil not fit for cultivation. Of the 66 acres 40 are plowed land.

The owner, like many of our best dairy farmers, does not attempt to follow a definite rotation over the whole of his cultivated land. Such a rotation will not produce what is needed in the proportion desired. On part of his land he usually adheres more or less closely to the following rotation, which moves about the farm as convenience demands:

Four acres of potatoes and roots.
Four acres of wheat with clover.
Then clover for two or three years.

Before a silo was built 4 acres of roots, usually mangel-wurzels and turnips, were nearly always grown. With silage so many roots are not needed, though some of them are always grown to give variety to the ration. The above rotation occupies about half the cultivated area and is not confined to any particular fields. The root crops are put in on any grass land which may need to be reseeded, just as is the case with corn on small, well-managed New England farms.

On the more moist land English rye-grass is sown with clover. The rye-grass seed is scattered broadcast on the newly sown wheat land in the fall and is covered with a weeder. The clover seed is sown in the spring just after a freeze, late in February or early in March. On the drier land orchard grass is used instead of rye-grass. Rye-grass is not grown to any extent in the United States except in western Washington. On moist land in that section it is a fine hay, pasture, or silage crop. It is practically an annual, but if properly managed it will reseed itself and make almost a permanent meadow on suitable soil. It thus reseeds itself on much of this farm.

The wheat in the rotation mentioned, as well as that grown elsewhere not in any regular rotation, is used partly for soiling, but is mainly grown for chicken feed. Wheat on the peculiar soils of these mountain valleys west of Puget Sound probably produces larger yields of grain than anywhere else in the world. Eighty-four bushels to the acre have been grown on this farm, and anything less than 60 bushels is considered a poor crop. Such crops could not, of course, be grown except on farms that have an abundance of manure. Singularly enough, none of the wheat grown in this (Jefferson) county can be used for bread making, because it is entirely too starchy. It is grown mainly for use as feed for poultry, but is also fed to live stock.

The remainder of the 40 acres of cultivated land is devoted to miscellaneous crops not grown in any regular order. Such crops as rye, wheat, barley, oats, wheat and oats, peas and oats, vetch and oats, etc., are grown for soiling, hay, or silage, as required. On some of the muck land not adapted to clover, turnips are usually sown about the first of July, to be followed by a mixture of redtop and rye-grass. This may be used for hay the next year, or it may be taken for pasture, a like area of other pasture land being plowed up. This muck land also gives good crops of wheat and oats. Wheat, barley, oats, etc., not in the regular rotation may or may not be followed by grass. Some barley for soiling is sown as late as August.

As already stated, a tract of about 20 acres of muck land was so full of sunken logs that it could not be plowed until these logs rotted. This piece of land was used for cow pasture for many years. By 1906 part of it could be plowed, and since then most of it has reached a condition that permits plowing. When any of it is plowed up, a like area of tillable land on the 40 acres previously mentioned is converted into pasture, so that there are always 20 acres of cow pasture. In addition, there are two pig and calf pastures of 2 acres each and a pasture of 1½ acres near the barn for the horses.

THE SILO AND THE SILAGE CROPS.

The silo, which is made of 2 by 6 staves, is 16 feet in diameter and 24 feet high. It holds about 65 tons of uncut grass and clover. If a new silo were built it would be made at least 30 feet high. The silo is lined with cement, the lining being renewed as occasion requires. No corn is grown, as this crop does not do well under the prevailing conditions. Peas and oats were formerly used largely for silage, but for the past few years peas have failed for some reason. Experiments with vetch as a substitute for peas have been made, and it has been found very satisfactory. One year when the peas were destroyed by worms the vetch was not touched.

Since peas began to fail, clover and English rye-grass have been the main dependence for silage. Rye-grass is a welcome addition to the clover, for the cows relish it greatly and it adds much to the yield. On the higher, drier fields orchard grass is sown with clover, to be used either for hay or silage. In 1907 the silo was filled with barley, on account of the failure of the peas in a crop of peas and oats, the barley being sown on August 10 and cut about October 15. The owner was led to use barley by the experience of another farmer who makes silage of barley without a silo, the green material simply being stacked and covered with 18 inches of earth.

When clover and rye-grass are used for silage the crop is cut about June 16 to 20, finishing by the time clover is in full bloom. Peas and oats are cut for silage when the oats are just entering the dough stage and the first peas are ready for table use. Cut at this stage the silage is sweeter than if cut earlier. If cut much earlier it is liable to develop a very unpleasant odor.

The materials used for silage on this farm have taught the value of thorough trampling in filling the silo, and the owner is of the opinion that improper filling accounts for much poor silage. Rye-grass is very heavy and packs well, but not so well as corn. In filling, two men are kept in the silo. The green material is spread evenly and trampled thoroughly next the wall. Trampling is unnecessary in the middle, where the green material falls. Unlike corn, the material is put in uncut, being elevated with an ordinary hayfork. Trampling around the walls is kept up at intervals as long as the silage continues to settle, say for ten to fourteen days after filling, depending upon the rapidity of filling. Rapid filling means long settling. The silo is filled to the top, then two or three loads a day are added for several days, as the material settles. The filling continues as long as the settling will permit the addition of a full load every other day, and when completed the silage is at once covered at least a foot deep with green marsh grass, well trampled and well wetted. The wetting is repeated daily for two or three days, and the trampling continues several days longer. For the wetting, water is drawn up in buckets from barrels in a wagon. Two barrels are sufficient for one wetting. It is easily seen that the men on this farm are more afraid of spoiled silage than they are of work.

THE HANDLING OF MANURE.

It goes without saying that on a farm as well managed as this good use is made of all the manure produced. It is hardly practicable under the conditions to haul the manure to the field every day, which is really the best practice where it can be done. The manure is removed from the barn daily, and every two weeks a general cleaning up occurs, all the manure available on the place being taken to the fields. It is spread on newly plowed land and on grass lands. Heavy applications are made on the garden and on land which is to be devoted to root crops. Every part of the farm receives manure in its turn.

THE DAIRY HERD AND ITS MANAGEMENT.

Like many a beginner, the owner of this farm started in with cows that did not belong to a dairy breed. These cows were Shorthorns. Some of the original stock were good milkers, but when a pure-bred Shorthorn bull was bought for $125 the heifer calves proved worthless in the dairy. This excellent beef bull had tuberculosis, and the owner got rid of him and all his get with comparatively little loss of time. About this time a dairy near by "broke up," and 6 really good Jersey cows were taken for their keep. After keeping them five years, 3 of them were purchased, as was also a registered Jersey bull, the first registered animal ever brought into the county. At that time the herd consisted of 16 to 18 cows. When the produce from this bull came to maturity the owner found he was on the right line, and his herd consists now of high-grade Jerseys and Guernseys.

In 1892 contagious abortion, the bane of dairy farming, broke out in this herd. Eighteen out of 19 cows aborted. In 1893 only 2 or 3 calves were born. About half the herd aborted in 1894. This incident well illustrates the reason why this farmer has been so successful. Most men would have given up dairying at this point. Not so with him. He wrote to the State veterinarian and learned how to treat the disease and then went to work and cured his cows.[a] Before the season of 1894 was over he had the disease completely mastered and has had no recurrence of it since. The loss of calves in 1892 and 1893, however, was a serious blow, from which it took several years to recover. The disease was introduced into the herd by loaning the bull to a neighboring dairyman whose herd was infected, a fact not known at the time.

The data for this bulletin have been obtained on three separate visits to Mr. Blanchard's farm—in 1905, 1906, and 1907. The following description of the dairy herd relates to the year 1905, when the herd was about at its maximum. The second son had just gone away to college, the oldest son having already graduated in agriculture and entered the service of the United States Department of Agriculture. Since that time the herd has been allowed to decrease in size, a corresponding increase in poultry compensating therefor. At that time there were 37 cows in the herd. From 9 to 12 heifer calves were saved each year, so that there were usually on hand about this number of yearling heifers and a like number of calves. Male calves were made away with as soon as born, as is the practice on most good dairy farms having grade cows. Not all the heifers were needed to keep up the herd, so a good many of them were sold. Experience has shown that after a herd is once built up it may be kept at a high degree of efficiency by using well-bred bulls and saving one-fourth as many female calves every year as there are cows in the herd. This means keeping half as many young females (calves and yearlings together) as there are cows. This enables the dairyman to replace not only the old cows that are beginning to fail, but also young cows that have not proved profitable.

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[a] Information regarding this treatment may be obtained from the various State agricultural colleges and from the U. S. Department of Agriculture.

Two bulls are kept, one younger than the other, so there is a chance to determine the value of a new one before an old one goes.

The owner endeavors to have most of his cows freshen in the fall, because of the higher price of butter in winter. It is not possible, however, to get all the cows fresh at this season. Usually about half of them bring calves in September and October, one-fourth during the winter, and one-fourth in the spring. This gives, under his conditions, a fairly satisfactory distribution of the product throughout the year. If all the product were sold to private customers it would be preferable to have the same flow of milk at all seasons, but the method of marketing, described later, makes it more profitable to have the largest flow of milk in winter. The smallest number of cows, 15 to 20, are in milk during August. During May and June, 32 to 33 are giving milk. Cows that freshen in the fall bring the largest annual income, other things being equal, since they give most of their milk during the season of high prices.

This herd contains no phenomenal milkers. A few of the best cows give more than 400 pounds of butter a year, yet the average yield of butter for 1905 was only 256 pounds for all cows, including dry ones. At least one-fourth of these cows were heifers with their first calves. The writer is inclined to attribute this moderate yield to the owner's system of feeding. He has never fed much grain, not over half as much as some dairymen feed. He has never thought it profitable to feed concentrates heavily. Considering the fact that butter is sold at market prices and that concentrates are relatively high priced, the system followed is probably correct in the main. Suppose 1,000 pounds more grain a year were fed to each cow and the butter yield thereby raised to 300 pounds; this grain, at $20 a ton, would be worth $10; the difference between 300 pounds of butter and 256 pounds is 44 pounds, which, at 26 cents, amounts to $11.44, or only $1.44 more than the value of the additional concentrates. These figures are only estimates. The actual results might possibly throw the balance on the other side. It is probable that this herd could easily be made to average 300 pounds of butter per cow if it were profitable to do so. If the owner were situated near a large city where he could sell all his butter or a large part of it at fancy prices (it is fancy in quality), he would be justified in feeding more heavily than he does.

There has never been a case of milk fever on this farm. The owner does not know whether this is due to his system of feeding or to the absence of phenomenal milkers. It is probably due to the latter, and that in turn to the system of feeding.

SYSTEM OF FEEDING DAIRY COWS.

Winter Feeding.

In winter dry cows are fed 10 to 15 pounds of roots (turnips or mangel-wurzels) daily and all the hay they will eat. The hay usually consists of peas and oats or rye-grass and clover, both excellent for cattle. As freshening time approaches the quantity of roots is gradually increased to twice the above amount, and bran is added. Under such conditions mature cows receive 4 pounds of bran a day by the time they freshen, heifers half this quantity and half as many roots. All cows are kept in the stable in winter, except for a short period each day when they are let out to drink while the stable is cleaned.

Cows giving milk during the winter are fed all the hay they will eat, which is about 12 to 15 pounds a day, besides 20 to 30 pounds of silage, 20 to 40 pounds of roots, and 4 to 8 pounds of bran and shorts daily. Bran costs $19 to $20 and shorts $20 to $22 a ton. They are mixed half and half by weight.

Summer Feeding.

Silage and roots are grown in quantities sufficient to last till soiling crops and pasture are ready in the spring. An acre of rye is sown in the fall for early soiling. This is followed by wheat. Soiling crops in summer take the place of silage in winter, and pasture takes the place of roots. While feeding green rye the bran and shorts are continued as in winter feeding, but as soon as wheat comes in for green feed the feeding of concentrates ceases entirely. Hay is fed the year round—all that the cows will eat. In winter, with roots, silage, and concentrates (bran and shorts), the cows eat 12 to 15 pounds of hay a day. In summer, with an abundance of green feed, they consume about 5 pounds of hay a day. Dry cows simply run on pasture in summer, receiving no other feed.

Soiling Crops.

When it is convenient in the cropping system, an acre of rye is sown in the fall for use as green feed in early spring. It is sown in October, and is fed about May 1 to 15. At the beginning of this period the rye has not yet headed out; at the end it is in the milk stage. Pasturing begins about the same time as soiling. The aim is to begin pasturing when the supply of roots is exhausted, and soiling when silage gives out. The feeding of bran and shorts ceases when the change is made from rye to wheat for soiling. One reason for this is that wheat is more palatable than rye, and the cows eat more of it. Another is that by this time the pasture is in excellent condition.

Wheat, which succeeds rye in the soiling system, is sown by the middle of October, sometimes as early as October 1. It is fed from May 15 to June 1, during which time about 1 acre of wheat is used. Clover may take the place of wheat in the soiling system. Both wheat and rye for soiling are sown very thick on the best land, 3 or 4 bushels of seed to the acre. This is low, moist land, which requires a higher rate of seeding for all the cereals than does drier land.

Usually by June 1 the pasture has become so productive that soiling may be dispensed with until the middle of July. During this month and a half the cows ordinarily receive no feed except pasture and what hay they will eat (about 5 pounds a day under these conditions). About the middle of July soiling begins again, on peas and oats or second-growth clover. These are cut from the regular hay fields and are fed for two or three weeks. After this specially sown fields of mixed grains, wheat, oats and peas, etc., are used for soiling until about October 1. Beginning June 1, an acre of these mixtures is sown about every ten days, the last sowing about July 4. The field sown June 1 is fed during the first ten days of August. Four sowings of mixed grains with occasional short periods of pasture on fields where crops have been cut (but never on the clover sod) suffice until about October 1. Beginning the middle of July, an acre of barley (White Hull-less, a beardless variety) is sown about every ten days or two weeks, the last sowing being made about the middle of August. Usually two or three sowings of barley are made. This crop is ready for soiling about October 1 and is available until nearly the middle of November, when the winter system of feeding begins. Barley sown late in the season in this manner comes on rapidly at first, but its later stages are retarded by cool weather in the fall, so that it remains in condition suitable for soiling longer than crops sown earlier in the season. Less soiling is also required in the fall, as a good many fields from which soiling crops have been harvested are available for pasture at this season, in addition to 20 acres of very rich permanent pasture. Barley is regarded as a fine soiling crop.

Gaps in this soiling system are filled by pasturing fields from which the crops have been harvested. The hay fields in the rotation are never pastured. Any surplus of a soiling crop is made into hay or silage.

As this soiling system is of special interest, it is given in tabulated form below.

Soiling system for dairy cows in use on the Blanchard farm.

Crop.	When sown.	When used.	Number of days used.
Rye	October	May 1 to 15	15
Wheat (or clover)	October 1 to 15	May 16 to 31	16
Pasture		June 1 to July 15	45
Peas and oats (or second-growth clover)	Spring	July 16 to July 30 or August 6	14 to 21
Mixed grains	June 1	August and September, with periods of pasture.	61
Do	June 12		
Do	June 24		
Do	July 4		
Barley	July 15	October and first half of November.	45
Do	July 25		
Do	Aug. 13		

MANNER OF HARVESTING CERTAIN CROPS.

For cutting soiling crops, silage, and grain hay Mr. Blanchard uses a side-delivery reaper that leaves the cut stuff in bunches very convenient for handling with a hand fork. In cloudy weather, soiling material is cut twice a week; in sunny weather, three times. It is immediately loaded upon a wagon and drawn to the barn where it is to be fed, and it remains on the wagon until used.

In curing grain hay cut in this manner, a few hours after it is cut four bunches are put together in a small cock. The next day these are made into larger cocks, which remain in the field until the hay is cured.

DAILY ROUTINE FOR COWS IN SUMMER.

A small feed of hay is given early in the morning. About 8 o'clock the cows are turned out to pasture. At noon they are stabled and given a feed of green forage. Another such feed is given at 3.30 p. m., and still another at 6 p. m., after which they are turned out to pasture for the night. The quantity given at each of these feeding periods is governed by the amount the cows will clean up. In feeding soiling crops it is important not to put too much feed before cows at a time. After they have mouthed over the green stuff for a while they refuse to eat it and call for fresh material. They should be given only what they will eat before they have fouled it too much to relish it.

When the hay is of the best quality, no grain is fed during the soiling period (except when rye is fed) even to fresh cows, but if the hay is not the best a small quantity of grain is fed fresh cows at the morning feed.

FRESHENING AND DRYING COWS.

Three weeks before a cow freshens, if this occurs during the winter feeding period, Mr. Blanchard begins feeding about 2 pounds of bran a day. No shorts are fed until after calving. This feed is gradually increased until at calving time the cow is receiving about 4 pounds of bran daily. After freshening, the cow's grain ration is gradually increased by adding shorts until the amount fed reaches a maximum of 8 pounds for the best cows in the herd. In the case of the smallest milkers, shorts are gradually substituted for half the bran after the cow freshens, so that these cows get only 4 pounds of bran and shorts as a maximum grain feed. The average cow in the herd gets about 6 pounds of bran and shorts when in full flow of milk in the winter.

An effort is made to have each cow dry from six to eight weeks a year. The cows are milked regularly twice a day up to within a week of the time they are to be turned dry. They are then milked once a day for three or four days, a small quantity of milk being left in the udder each time. After this they are turned out to pasture and are not milked again until the next period of lactation begins.

CARE OF THE BULLS.

The two bulls are kept together in a lot. They get a good deal of exercise by "scrapping" with each other. They are fed much the same as the cows. The reason for keeping two bulls, as already stated, is that it affords a chance to test the new one before an old bull of known merit is disposed of.

REARING THE CALVES.

The owner of this farm prefers to raise fall and winter calves for the dairy. It is more convenient under his conditions to give them the attention they need than in the case of those born at other seasons. The calves are allowed to nurse their dams only once. After this they are fed their mother's milk for two weeks. The first week they are given 2 quarts of milk in the morning, 1 quart at noon, and 2 quarts in the evening. The second week they are given 3 quarts twice a day, morning and evening. During the next two weeks the feed of the calf consists of half whole and half skim milk, with a pinch of flaxseed meal (made by grinding the whole seed) added to it, about 1 ounce at a feed. The quantity of milk fed during this period (the second two weeks) is about 3 quarts twice a day.

After the calf is a month old it is given 4 quarts of skim milk twice a day with an ounce of flaxseed meal and a handful of mixed corn meal and ground oats. The calf is taught to eat this by putting the mixture in the milk a few times. Then the grain is fed dry, after the skim milk. Feeding this dry material after the skim milk is finished prevents the calves from sucking each other when they are let out of the stanchions in which they are fed. The quantity of grain is gradually increased until at two months of age the calf is receiving a quart of the mixture a day. About this time the feeding of a small quantity of roots and silage begins, and the calves are given all the hay they will eat. Milk is fed until the calves are six months old, sometimes longer. They have access to fresh water at all times.

The calves are fed in stanchions, as shown in figure 1. These stanchions are very convenient and are easily constructed.

In spring the calves are turned out to pasture in a small inclosure made for their use. As they begin to eat grass freely, they are fed less milk, grain, etc., though, as previously stated, milk is fed more or less until the calves are at least six months old. During the next fall and winter they are given rations similar to those of cows in milk, but smaller in proportion to their size.

The owner cautions against breeding heifers too soon. He says that heifers should not bring calves under twenty-five or twenty-six months of age, and thirty months is better. Make winter cows of as many of them as possible; enough will go over till spring anyway to give needed cows at other seasons.

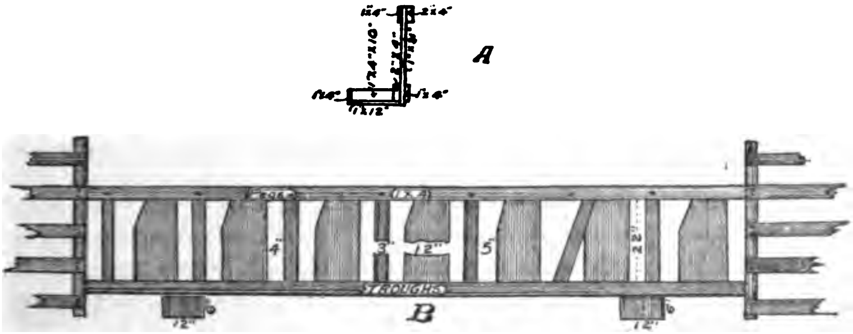

FIG. 1.—Calf stanchions. *A*, cross section showing dimensions and details of construction; *B*, front view. These stanchions form a section of a fence, as shown at ends. The 12 by 6 inch blocks under the troughs are supports for the structure. The long trough is divided by partitions into 15-inch and 9-inch compartments, alternating with each other. The 15-inch compartments are in front of stanchions and form the feeding boxes. The 9-inch spaces are not utilized.

DISPOSING OF THE PRODUCTS OF THE DAIRY.

The only dairy product sold is butter. The skim milk is fed to pigs and poultry. In 1905, 3,120 pounds of butter were sold on contract to one merchant at 26 cents a pound the year round. The merchant has regular customers for this butter. An attractive exhibit recently made at a fair in the market town considerably increased the number of these customers. Another merchant who makes a special feature of the brand bought 5,460 pounds at creamery prices. The price received for this portion of the product was on the average about the same as for that delivered on contract.

About 400 pounds were sold to miscellaneous customers during the year. The total quantity sold during 1905 was 8,980 pounds, which at the average price of 26 cents brought $2,334.80.

In addition to this the family used all the milk, cream, and butter wanted, probably the product of two cows. It is fair to assume, therefore, that 35 cows out of a total of 37 on hand during that year produced the 8,980 pounds of butter sold. This is at the rate of 256½ pounds per cow per year, as already stated.

HOGS.

Two or three good brood sows and one boar are kept on the farm. The owner butchers during the year 35 to 40 pigs, weighing from 150 to 160 pounds each, dressed weight. What meat is not required for home use is sold to butchers in the market town 12 miles away and brings 7 to 8 cents a pound. There is no difficulty in selling all the meat produced, and the same is true of all the products of this farm. The more there is to sell the easier it is to sell it. Butchering is done twice a year, in the fall and in the spring, when the pigs are six months old. The total income from this source is about $400 a year.

MANAGEMENT OF PIGS.

The sows farrow twice a year, in March and October. They run on good grass pasture at all seasons. They share 5 acres of such pasture with the calves, horses, and pigs, though horses and pigs are not in the same inclosure at the same time. For about a month before farrowing time the sows, in addition to pasture, are fed roots—any kind on hand—and a little shorts in skim milk. The first two days after farrowing the sows are fed very lightly. After this the feed is increased until in a few days they are receiving 1 quart of shorts three times a day and all the skim milk they will eat. They are also given what roots they want until pasture becomes abundant. In the case of fall litters the feeding of roots continues until the pigs are weaned, which occurs when they are 6 weeks old. After weaning time the pigs are fed three times a day all the shorts, skim milk, and roots they will eat in addition to pasture, roots being omitted when pasture is very abundant. When the pigs are 5 months old coarse corn meal is substituted for shorts. They are then confined in pens, but are fed some green stuff daily.

When not suckling, the sows depend entirely on pasture, if it is sufficient to keep them properly. If not, they are fed enough shorts, skim milk, roots, etc., to keep them in good condition. As previously stated, heavier feeding begins about a month before farrowing time.

POULTRY.

During the past few years the poultry business has grown to equal the dairy as a source of income on this farm, and now actually exceeds it. Common hens of no particular breed were used at first. Within a year or two the business grew to such proportions that Mrs. Blanchard began to employ much of her time in connection with it. At the present time the mother and daughter care for 500 hens and their product, while the father looks after an additional 200. Poultry has paid from the beginning. As the boys go away to college, the poultry business is gradually replacing the dairy, as the work is lighter and the remuneration greater, especially since a good market has been obtained for eggs for hatching purposes.

On this farm it has been learned that well-bred fowls pay better than those of no particular breeding. It has also been learned that fine feathers and egg laying do not always go together. The hens on this farm have been bred for egg production, and last year a pen of 30 hens laid an average of 186 eggs each. There are probably few flocks of hens in this country that lay more eggs on an average than those on this farm. Some of the best hens are believed to lay 250 eggs a year, or very nearly that number. Trap nests are not used, but all who look after the poultry are excellent judges of egg-laying qualities as indicated by form and other characteristics. Good layers only are selected for the breeding pens.

The breeding of pure-bred fowls was begun with the Barred Plymouth Rocks, and this breed is still the leading one on the farm. As a market was built up for eggs for hatching, customers began to call for eggs of other breeds. The most frequent calls, after Barred Plymouth Rocks, being for Brown Leghorns, that breed was next introduced. Others were selected as the market demand for eggs indicated, so that now, in addition to Barred Plymouth Rocks and Brown Leghorns, flocks of White Plymouth Rocks, Black Minorcas, and White Wyandottes are maintained.

POULTRY HOUSES.

While the poultry houses on this farm are not expensive, they are eminently practical and have been designed with a view to convenience in management, comfort and cleanliness of the fowls, and protection against enemies of all kinds. There are no losses from weasels or other small animals, for these pests of the poultryman are completely fenced out of the laying, breeding, and brooder houses. The houses for the laying pens cost about $1 per hen. In one of the groups they are so well planned and answer their purposes so perfectly that they are here described in detail.

Figure 2 shows the general plan of the houses and runs. The latter, however, are not arranged as they would be if the proper space had been available, but they are drawn as they actually are in order to illustrate methods of making runs fit the available space. A building 128 feet long and 10 feet wide is cut into eight rooms 10 by 15 feet and a storeroom for feed 8 by 10 feet. It will be noticed that one of the runs on this side extends beyond the end of the building. This arrangement was made necessary by the nature of the space available. In each of the eight compartments with runs attached 30 hens are kept. The floor space in the building is 5 square feet for each hen and in the runs 135 square feet. Some good poultrymen give each hen only 4 square feet within doors, so the allowance in this respect is liberal. Even with 135 square feet of outdoor space for each hen not much of a growth of green stuff can be maintained in the runs, the space being intended more for exercise than for pasture.

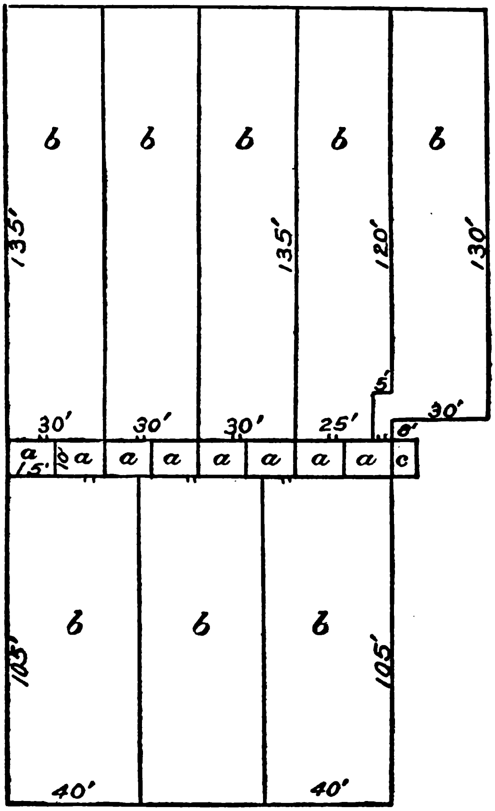

FIG. 2.—Plan of poultry buildingand yards: *a*, Compartments or pens. 10 by 15 feet, for 30 hens each. There are 8 pens and the entire building is 128 feet long. *b*, Yards or runs, one for each pen. Five of the yards are situated on one side of the building and three on the other; they are approximately equal in area. *c*, Feed room 8 by 10 feet.

In figure 3 is illustrated the end of the building in which the feed room is located. Figure 4 shows the front of one of the 10 by 15 foot compartments occupied by 30 hens. The doors, *A*, *A*, consist of an inner and an outer shutter, the inner covered with No. 10 muslin, the outer with chicken wire.

Figure 5 gives the ground plan of one of the compartments or pens. Dirt floors are used. The self-feeders and the drinking pans are placed in appropriate openings in the partitions between two pens. The doors are 4 feet wide and 6 feet high and swing both ways. The upper half of each door is of chicken wire, the lower half of boards.

The two perches are on a level with each other, so that there will be no crowding on the top perch. They are placed 15 inches above the dropping board. Figure 6 shows how the perches are supported. They do not touch the walls of the room at any point. This is important, as it aids in keeping down vermin. The self-feeders are mentioned later.

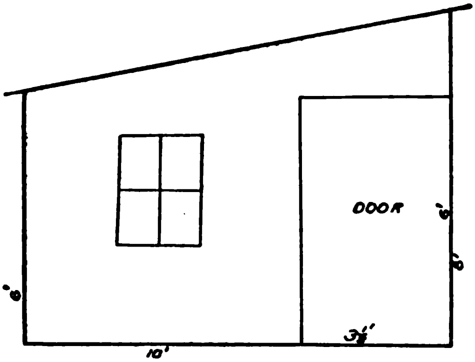

FIG. 3.—End view of feed room in poultry house.

As shown in figures 6 and 7, the perches and nest boxes are supported entirely by suspension from the rafters. The supporting frame does not touch the walls at any point. The hens enter the nests from the rear, where the nest boxes are boarded up only half way. The board on which the boxes rest extends 6 inches beyond the boxes at the rear to form a platform on which the hens alight when they fly up to the nests. The bottom of the nest boxes is 2 feet from the ground. The dimensions of the various parts of the supporting frame are shown in figure 7.

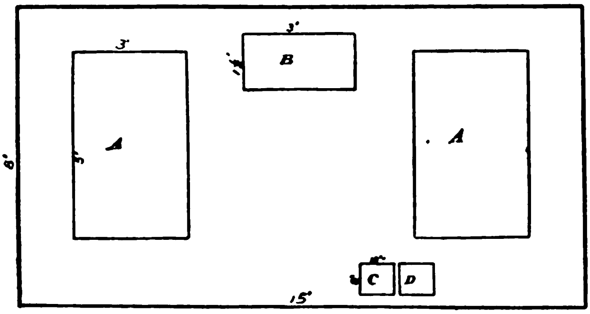

FIG. 4.—Front view of a single compartment of the poultry house. *A*, *A*, Doors 5 by 3 feet, each having two shutters, one opening inward, covered with No. 10 muslin, and the other opening outward, covered with chicken wire; *B*, ventilator 1½ by 3 feet, with muslin-covered shutter hinged at top and opening inward so it can be propped open; *C*, opening 8 by 10 inches between pen and yard for passage of hens; *D*, sliding cover for *C*.

These houses are not artificially heated at any season of the year. On the coldest nights during the winter the openings (doors, windows, and passageway for hens) are all closed, the ventilation being entirely through the muslin doors (fig. 4, *A*) and the muslin-covered ventilator (fig. 4, *B*). In cold weather the fowls must not be exposed to drafts.

VERMIN.

Vermin (mites) are the bane of improperly managed houses. They conceal themselves on the undersurface of the perch, in the corners of nest boxes, under the dropping board, and in crevices wherever convenient to the roosting places of the fowls. In these places of concealment the vermin deposit their eggs. Once every year every possible hiding place for vermin is painted with a coal-tar preparation. This is applied full strength with a brush. The whole inside of the nest boxes is thus painted. This treatment keeps the vermin in subjection.

The dirt floors of the pens are usually covered several inches deep with straw, which is changed about every ten days. In summer the floors are swept clean about once a month; in winter, less often—usually twice during the season.

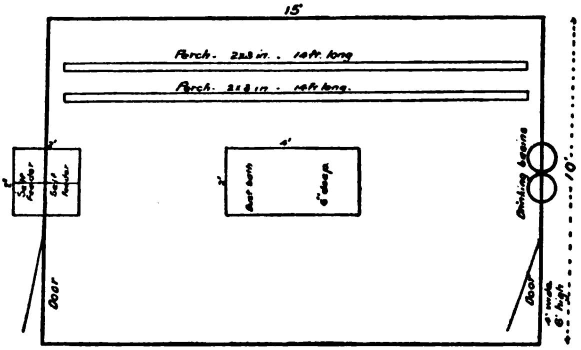

FIG. 5.—Ground plan of a compartment of poultry house.

The interior of these houses is whitewashed once a year, a pint of disinfectant being added to each bucket of whitewash. This aids in keeping down vermin. The fact that the perches and nest boxes are swung from the rafters and nowhere touch the walls prevents mites from hiding in crevices in the walls.

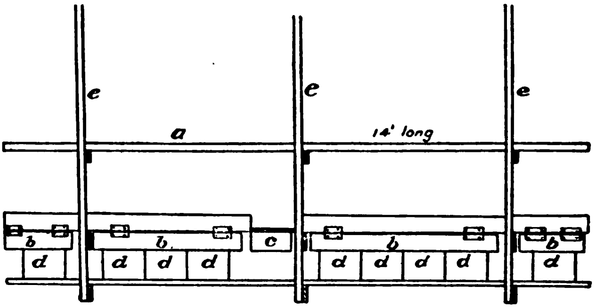

FIG. 6.—Front view of perches, nest boxes, etc.: *a*, Perch 14 feet long, 15 inches above platform, and about 20 inches below rafters, and not touching wall at either end; *b*, hinged shutter to cover front end of nest boxes; *c*, sloping board to facilitate raking out droppings from platform; *d*, *d*, *d*, nest boxes, 12 inches wide, 8 inches high, and 10 inches from front to back, boarded up half way in rear; *e*, *e*, supports attached to rafters.

The owner estimates that with houses constructed as these are one man could take care of 1,500 to 2,000 hens. In 1905 he had about 500 laying hens, but the number has increased since then. At that time he hatched 1,000 young a season. Half of these would of course be males. From the remaining half he was able to secure enough good pullets to replace discarded hens. Only pullets are used in the laying pens. The best of these are retained for the breeding pens the next year. Occasionally a hen of exceptional merit is kept in the breeding pen during her third year. A few of the best pullets, especially those that begin laying very early, are put in the breeding pens the first year.

The houses here described are for laying hens only. The breeding pens are similarly constructed, but are not so large, since fewer hens are kept together (see p. 38).

INCUBATION.

For the first nine years only hens were used for hatching. The Barred Plymouth Rocks were used mostly for this purpose, as this breed is more inclined to broodiness than the Leghorns. The tenth year incubators were installed and were successful from the start. They are now used exclusively except when it is desired to keep a few specially selected eggs separate or to start eggs to refill the incubators when infertile eggs are tested out.

Eggs are always gathered in the evening after feeding time. Those from the breeding pens are placed in a basket having separate compartments for each pen. A record book is kept in this basket and as the eggs are gathered the number obtained from each pen is recorded. Eggs intended for hatching are placed in egg cases in a room having a temperature of about 55° F., and the cases are turned every day so there will be no tendency for the yolk to settle to one side of the egg. Other eggs are kept in a cooler room.

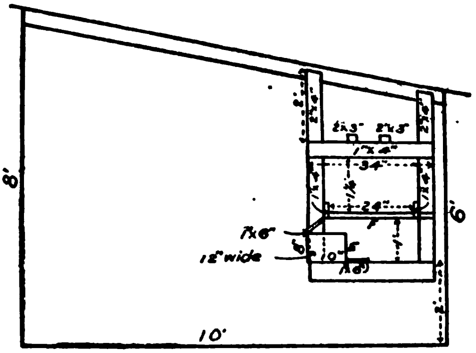

FIG. 7.—Cross section of poultry pen, showing method of supporting nests and perches.

The incubator room is built entirely above ground, though it is recognized that a cellar or half cellar would be preferable in a section where sudden changes of temperature are likely to occur. In the vicinity of Puget Sound the climate is quite equable, so that the above-ground structure answers very well. This building, however, is ceiled inside to protect against sudden changes of temperature.

The incubators are started about January 15 to 20. Two days before the eggs are put in, the machines are thoroughly cleaned and aired and the lamps filled and lighted. This is necessary to get the incubators heated and regulated. The temperature is adjusted to 102½° F. Enough incubators are kept to hold 500 eggs, and usually four hatchings are made, requiring a total of about 2,000 eggs. The first two hatches are usually from the heavier breeds, the later ones from the smaller breeds, for the reason that the large fowls develop more slowly and by hatching them earlier the pullets come to maturity more nearly at the same time with Leghorns and other small breeds.

During the first two days in the incubator the eggs are left undisturbed; after that they are turned over twice a day. On the sixth day the eggs are candled, and those in which there is no sign of a developing embryo are removed. Eggs thus removed are boiled hard and used later as chicken feed, as described farther on. When the incubators are started, either a few hens are set or a small incubator is filled, and these eggs are used in replacing those tested out from the large incubators. This is an economy well worth while if facilities are at hand for it, as it runs the large incubators at their full capacity. It costs no more to hatch 300 eggs in a 300-egg incubator than it does to hatch 200 in the same incubator.

On the nineteenth day the eggs are candled again, and all that do not show well-developed chicks are removed.[a] Hatching begins on the twentieth day. At the end of the twenty-first day the egg trays and all shells and other litter are removed. The chicks are left in the incubators twenty-four hours longer, during which time the temperature is gradually lowered to about 95° F. They are then removed to the brooders and receive their first feed and drink.

PERCENTAGE OF HATCH.

From 65 to 75 chicks from 100 eggs is regarded as a good hatch, and 80 as extra good from eggs of which 90 to 95 per cent are fertile. A number of chicks die by the time the point of the bill breaks through the shell. They do not seem able to extend the rupture in the shell beyond this point. Some poultrymen attribute this to inherent weakness in the chick, while others think it is because the chick fills the shell so completely that it is unable to move sufficiently to extend the break. It may sometimes be due to shells that are too strong for the chicks. We see here a case where natural selection bears a heavy hand on the unfortunate individual which varies in such a way as to be unable to pass this narrow portal in the life of the chick.

THE BROODERS.

Not less than a week before the first hatch is off, the brooders are thoroughly cleaned and then disinfected by painting all the woodwork with a disinfectant. When the chicks first begin to hatch, two days before they are removed to the brooders, the brooder lamps are lighted and so regulated that the temperature is about 95° F. Sand thoroughly dried in an oven is spread while yet warm about an inch deep on the floor of the brooder, and this is covered half an inch deep with fine chaff secured from the mangers, barn floor, etc. On this, under the hoverer, the brooder thermometer is placed. When this stands steadily at 95° F. the brooder is ready for the chicks.

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[a] This is contrary to the rule generally followed, which forbids the touching of eggs in an incubator after the eighteenth day.

In removing chicks from incubator to brooder great care is used not to allow them to become chilled. They are moved during the warmest part of the day in a basket lined with a warm blanket, part of which is folded over them. This care is made necessary by the fact that the incubators and brooders are in different buildings.

As soon as the chicks are placed in the brooders, food and water are given them. For the first three days they are confined to the brooders, and are fed three times a day. Only 50 are placed in brooders having a rated capacity of 100, experience having shown that better results are secured thereby. At the end of the third day the gate is opened to permit the chicks to enter the runway. The brooders are so placed that their runways have direct sunlight through the windows of the brooder house, as sunlight is regarded as an important agency in keeping the flock healthy. The floors of these runways are covered about 2 inches deep with chaff.

During the first week the temperature of the brooder is gradually reduced until at the end of the week it is 90° F. Thereafter the temperature is lowered at the rate of 5 degrees a week till it reaches 65° to 70° F., at which it remains as long as the chicks stay in the brooder house. In order to make room for another hatch the chicks, by the time they are 4 or 5 weeks old, are sometimes transferred to an adjoining brooder room, where the temperature is not so high.

Just outside the brooder house are a number of small yards, or runways, one for each brooder. After the chicks are about 6 days old, if the weather is favorable, they are allowed the freedom of these outside yards, which are kept clean and are frequently spaded up. The young birds enjoy scratching and dusting themselves in the loose dirt. They spend the nights under the hoverers of the brooders until they attain the age of 5 to 8 weeks, the length of this period depending on the weather and on the date of hatching. Early hatched birds stay in longest. Six weeks is about the average length of the brooder stage.

If the chickens remain outside the hoverers after their usual roosting time in the evening it is probably too warm under the hoverers. In this case the temperature should be lowered. If they are inclined to huddle together at times when they should not be at roost they are probably too cold. Too much heat is considered more detrimental than not enough. In cold, bad weather the brooders are covered with blankets to insure proper temperature.

At the end of the brooder period the chicks are removed to an ordinary roosting house on the range.

FEEDING THE YOUNG CHICKENS.

For the first 6 days a commercial chick feed is used, consisting of cracked grains, such as wheat, oats, corn, millet seed, weed seed, charcoal, grit, egg shells, meat scraps, etc. There is some difficulty in getting this material properly made; in some cases it has contained ten times as much rock for grit as is needed. Part of this food is placed in shallow saucers and the remainder scattered among the chaff. The chicks are fed three times a day at this period. When they have learned to scratch for their food, which they will do in one or two days, the saucers are removed and all the food is thrown among the chaff. It is important that the young birds should be active, so scratching for this food is good exercise. Clean water is kept before them at all times.

When the chicks are let into the outdoor runs, which is about the sixth day if the weather is suitable, skim milk is added to the ration. This is fed once a day, in the morning, and is placed in drinking fountains in the outside runways. The quantity of milk fed is determined by what will be cleaned up within a short time, for it is not allowed to stand in the fountains all day. Meanwhile the drinking fountains in the brooders are kept supplied with water and can be removed to the outside runways when so desired. At this period one or even two of the three daily feeds of the commercial chick feed may be replaced by the "johnny cake" described later. When the chicks are about 3 weeks old the commercial feed is gradually replaced by a mixture consisting one-half of whole wheat, one-fourth of cracked corn, and one-fourth of steel-cut oats. This is thrown in the litter in the inside runways, mornings and evenings, in quantity a little less than the chicks will eat. In the middle of the day 50 chicks receive in place of the grain mixture a piece of homemade bread, called "johnny cake," about 6 inches square and 2 inches thick. This is made of one part oatmeal, two parts corn meal, a little whole wheat flour, a pinch of salt, and infertile eggs from the incubators, the whole mixed with sour milk and soda. From 2 to 6 eggs are used in a johnny cake 18 inches square and 2 inches thick. The rule is to feed half to two-thirds of what the chicks will eat of this cake, and never to feed anything in such quantity that portions will be left to be trampled on after the chicks have lost interest in it.

In addition to the mixed grains and cake, a small quantity of some succulent material is thrown into the runways. For this purpose grass, apples, carrots, kale, lettuce, and the like are used. Kale is much relished, and lettuce is one of the best feeds of this kind. The quantity of this material fed may be judged from the statement that one apple or one leaf of kale is given to 50 small chicks.

Chickens will not scratch when they are overfed, nor when there is no feed in the litter. The idea is to keep them scratching.

The changes in rations are made gradually. Disorders are easily caused by sudden and radical changes of feed. During this period finely chopped meat or fresh beef scrap is fed sparingly. The chicks get a good many angle worms from the freshly spaded soil in the outside runs.

Scrupulous cleanliness is observed about the brooders and runways. Everything is carefully disinfected by the free use of disinfectants before the chicks are placed in their quarters. This prevents trouble with vermin and sickness. Any chicks that do not show growth and activity from day to day are immediately removed, thus insuring the strength and vigor of the flock.

MALES AND CULLS.

About the time the chicks are removed from the brooders, or as soon thereafter as practicable, all the young males not wanted as breeders and all females that are in any way defective are removed to the fattening pens. About one-tenth of the females are thus discarded. It does not pay to make a specialty of broilers, as there is no good local market for them; but large quantities of eggs are sold to those near the large cities who make a specialty of raising broilers.

These surplus birds are given quarters to themselves, consisting of pens with runways attached. Young chickens do not thrive if confined too closely. The more range they have the better. They are fed on a crumbly mash made of four parts of corn meal, two parts of middlings, and one part of beef scraps, and wet with warm skim milk fresh from the separator. If the milk is lacking, water may be used. As much of this feed is given twice a day as will be eaten up clean quickly. Any refuse food remaining an hour after feeding time is removed from the troughs.

Selling begins about a week after the culls are put in the pens, and the lot is disposed of as rapidly as the market will take them. They usually weigh 1 to 2 pounds by the time they are sold and bring 25 to 50 cents each.

The quarters in which these culls and surplus males are fattened are kept as scrupulously clean as any others. Free use is made of whitewash and air-slaked lime, while disinfectants are used on the perches to kill any mites that may chance to be present. A large dust bath is provided, and plenty of grit and fresh water are supplied.

Before the young birds have learned to roost on perches, clean straw is kept on the floor of the roosting room. The chicks sit on this straw at night. To prevent crowding in the corners of the room, which is sure to occur unless provided against, the straw is piled high in the corners, so that it slopes downward toward the center of the room. When closing up the house at night to keep out enemies, a few chicks may be placed on the perches which should be low enough to be reached without difficulty. A cleated board slanting from the floor to the perch should be put up. In a short while the whole flock will take to the perches.

MANAGEMENT OF MALES SELECTED AS BREEDERS.

Both the young males and the young females retained in the flock are housed and taught to roost as just described for those in the fattening pens. They are fed differently, however, and are given much more range.

The young cockerels to be kept for breeding purposes are separated from the pullets as soon as they leave the brooder houses. The first incubation produces usually about 400 birds, 200 of which are males. Of these males 40 to 50 are retained as breeders. Before the breeding season begins about half of these have been disposed of—the poorest for meat and the others to farmers for breeding purposes—at from $1 to $2 each, according to quality. The plan is to keep for home use 15 cockerels where 10 are needed, so there may be a reserve on hand.

When the young cockerels are removed from the brooder house they are given a house out on free range. This house is placed in any convenient place on the farm, usually out in some field not occupied by a crop which the chickens will injure. It is moved about as convenience requires. A clover field is an especially desirable range. If the young birds are shut up in their house for a couple of days when first placed in it they will thereafter return to it to roost.

The feeding of these cockerels while on the range is similar to that of the pullets, described later. The cockerels remain on range until the breeding pens are made up in December.

CARE AND MANAGEMENT OF PULLETS.

When the young females are removed from the brooder houses they are divided into flocks of about 80 each and placed in small houses especially constructed for them. These houses are 5 by 10 feet, and may be moved about as desired. They are placed in any convenient subdivision of the farm, each pen of 80 being given an acre of range. On an exclusive poultry farm less space would be used, but space is abundant here and the young chickens, both male and female, are given considerable range. They are taught to roost, and are prevented from huddling together in corners at night in the manner already described.

As in the case of the males, the females are kept shut in their pens for two days after the pens are located in the fields. After that they range near their pens and return to them at night, when they are carefully shut in to keep away enemies. Clover range is preferred for these young chickens, but the houses are located in a pasture, wood lot, or anywhere else where land is available. For a year or two a small plat of alfalfa on some high land near the house was used, and this proved to be excellent range. These pens are always kept away from the ranges occupied by laying hens.

The pullets and cockerels on range are fed all they will eat once a day, at night. The feed consists of mixed grains such as wheat, oats, barley, etc. Skim milk and water are given them freely. Much care is used to keep the milk vessels clean.

Some of the most precocious pullets, especially of the smaller breeds, begin laying at about five months of age. Some time before laying begins they are removed to the laying quarters, which have already been described (figs. 2 to 7). The older hens have meanwhile been sold or transferred to the breeding pens. After the pullets are removed to their new quarters they are fed as if they were laying hens.

In each laying pen 30 pullets are placed. These pens are 10 by 15 feet, with runs attached containing about 135 square feet to the hen. Careful watch is kept of these pullets, as those which begin laying early are almost invariably the best layers. Some of the best are later removed to the breeding pens. If any of the young females do not come up to the required standard they go to market. No males are allowed in these laying pens, except in special cases in which some of the eggs are to be used for hatching.

SELECTING LAYERS AND BREEDERS.

In making up the laying and breeding pens, the first consideration is stamina, if eggs are wanted. Stamina is not so important if the breeder merely desires fancy points. On this farm the requirements of fashionable breeders are not very closely adhered to. It is found impossible to do so and to maintain as high an average yield of eggs as when less attention is paid to fancy points. The owner, who has bred up a good herd of special-purpose dairy cows after having first failed with a general-purpose breed, says that breeding for fancy points and egg production together is like trying to breed general-purpose cows. It is vastly more difficult than to breed for egg production alone. That he has succeeded in breeding for eggs is easily seen when a pen of 30 pullets in 1905 laid an average of 186 eggs during the season. Although not unmindful of breed requirements, an exceptional layer is not sacrificed because of some breed requirement that has no relation to egg production. Having 500 yearling hens and as many pullets from which to select less than 150 breeders, it is easy to secure good layers sufficiently near to breed standards to satisfy any reasonable requirement.

AGE OF HENS.

Pullets intended for the laying pens are hatched between February 15 and May 1. The larger breeds are hatched from February 15 to April 1; the smaller breeds from March 15 to May 1. Although the pullets do not usually molt, they sometimes partially do so in the fall. This interferes with laying, as hens do not lay well when molting. Since the yearling hens molt in September and October it is important that the layers should be pullets. Two-year-old hens molt a month later than yearlings.

No hens are kept beyond their first laying period, except those that are known to be excellent layers. A good pullet usually lays fairly well the next year. The breeding pens are made up mostly from those yearling hens that did best as pullets. If there is any shortage of these, the most promising of the new crop of pullets are selected. Only the most vigorous and most mature pullets are used as breeders. Occasionally a hen of exceptional merit is kept as a breeder the third year.

The Blanchards are much interested in the question whether pullets are born with a tendency to produce a small or a large number of ovules, and they believe it desirable that this problem should be studied by competent investigators. If pullets are all born with the inherited power of producing a large number of ovules, then proper care and management ought to give large yields of eggs. If they vary greatly in this inherited tendency, then no amount of care will make good layers of some hens. From theoretical considerations and the fact that different hens with the same care lay widely different numbers of eggs, the writer is inclined to the view that inheritance is highly important in the matter of egg laying. Otherwise, such increase in egg production as has been secured by using as breeders hens of known excellence as layers would not have occurred, unless, of course, this selection simply resulted in building up a flock of good layers adapted to the particular methods of management used.

An interesting fact which has developed in the experience on this farm is that greatly increased egg production in the two larger breeds (Barred and White Plymouth Rocks) is accompanied by a decrease in the percentage of fertility in the eggs. At the same time the number of chicks that fail to hatch properly increases. This is not the case with the smaller breeds (Brown Leghorns and Black Minorcas). The White Wyandottes are intermediate in this respect.

Experience on this farm also shows that some hens lay no eggs; others lay 35 to 40; some lay 200; and occasionally one lays as many as 250 in a year.

The farmer whose hens average 50 eggs each can easily improve this average by breeding from his best, as has been done on this farm. Of the five breeds kept, all have been successfully bred for high egg production.

As is the case with breeders of all kinds of stock, improvement at first is easy. But as a flock or herd is built up to a high standard it becomes increasingly difficult to make further improvement. When a large number of breeders are working along the same lines, the problem is easier. Unfortunately, most poultry breeders who have produced flocks of high excellence have been breeding for fashionable points, frequently to the utter neglect of egg production. The owners of this farm have great difficulty in securing new breeding stock so as to avoid too much inbreeding. Their experience with stock bought from prize-winning flocks has often been very unsatisfactory. On one occasion four fancy cockerels were bought from a prize winner. Three of them proved to be worthless; one of them did not fertilize a single egg. On another occasion two cockerels and four pullets were secured from the flock that had won more prizes than any other on the Pacific coast. One of these cockerels was placed in a pen of excellent hens. In the next generation the egg production was wholly unsatisfactory.

The difficulty just mentioned is not so great in the case of Leghorns as it is with other breeds, especially with Plymouth Rocks. High egg production is more firmly established in the Leghorns, and even the breeder for fancy points may maintain a high standard of egg production in this breed if he selects with sufficient care.

On this farm fowls are never inbred more than one or two generations. When inbreeding is practiced at all, careful watch is kept and a change is made at the slightest indication of need of it. It is often necessary to inbreed because of the difficulty of getting satisfactory breeding stock from others. It has never been found satisfactory to use young males and young females of the same breeding. It is considered better to breed an old bird to his or her offspring.

There has been some trouble with white feathers in the Minorcas and Leghorns, especially when inbreeding is practiced. These feathers disappear before the first molt and do not reappear. Such fowls are never put into the breeding pens, but if otherwise satisfactory they are used as layers of market eggs. This difficulty in the case of Leghorns is believed to have originated from some stock obtained several years ago from a distant State. There is some indication that this defect is a recessive Mendelian character which only crops out when both parents possess the defect, and then in only one-fourth of the progeny. It has no effect on egg production.

There has been some difficulty in keeping the combs of the Plymouth Rocks from getting too large. Some strains of this breed seem to run to large combs.

In breeding Plymouth Rocks for layers the weight has fallen below score-card standards. Little attention is paid to this point. The owner of this farm thinks the standard weight of this breed may be important for the broiler trade, but not for egg producers.

CARE AND MANAGEMENT OF LAYING HENS.

The pullets and hens are divided into two groups, the larger number, all pullets, having no males in their pens and are intended to supply eggs for market only. These are referred to here as the layers. The other group is known as the breeders and their pens are called the breeding pens. The breeders are chosen from among the best layers of the preceding year, together with some pens of promising pullets—that is, pullets of unusual vigor and early development, especially those that begin laying at an early age. Occasionally a hen of unusual excellence is kept in the breeding pens the third year.

By August all of the previous year's breeders except the occasional hen of unusual excellence have been disposed of; likewise all of the preceding year's layers except those reserved as breeders. About this time the layers kept over for breeding purposes are placed in the breeding pens and the pullets are brought in from their ranges and installed in the laying pens, the overflow going temporarily to what breeding pens may be empty.

No males are put into the laying pens unless it is desired to secure eggs for the incubator trade. The hens in these pens are good layers, but are not so carefully selected for breed characteristics as are those in the breeding pens. These eggs are excellent for broiler producers, as they produce vigorous chicks. When using laying pens for securing fertile eggs, two males are placed with each pen of 30 hens and the hens are handled as described for breeders.

Hens in laying pens with no males are not kept in their runs as strictly as breeders are. When the weather is suitable they are allowed free range, after having been confined long enough so that each hen will return to her own pen at night. Breeders during the breeding season, which lasts from December until June, are kept strictly segregated and are not allowed out of their pens and runs.

A great deal more care is required to get hens to lay regularly out of the usual laying period, which is in late winter and early spring. By using pullets only in the laying pens the owners get a large supply of market eggs in the fall and early winter when older hens are molting and fresh eggs are scarce and high priced.

BROODY HENS.

The hens are carefully shut in at night to prevent loss from owls, weasels, etc. Every evening, when the hens are shut up, a search of the nests is made for hens beginning to sit. If any are found, unless they are needed for hatching some small lot of eggs or for starting a few eggs to refill incubators when the infertile eggs are tested out, they are put in a small separate pen maintained for this purpose. This pen has the usual runway attached, but there are no nests in it. It is highly important that broody hens, unless it is desired to have them sit, should not remain on the nest overnight. If taken in hand the first day they are easily broken from sitting. The remedy used for broodiness is to put the hens where there are no nests, and do this promptly. Late in the season hens are more persistent about sitting. Older hens begin laying later in winter and get broody later. Those that begin laying early get broody early, if at all.

If broody hens are properly fed they will soon begin to lay again; they are then returned to their proper pens. Plymouth Rocks are more inclined to broodiness than Leghorns and Minorcas. Late in the season, near the molting period, even Leghorns are inclined to become broody.

FEED OF LAYING AND BREEDING HENS.

The system of feeding laying hens is similar to that for breeders. The laying houses are shown in figures 2 to 7. The floors of these houses are usually covered 4 to 6 inches deep with straw in order that the hens may obtain the exercise they need by scratching in it for their grain. Part of the feed is given in the hoppers (self-feeders) shown in figure 5. The hoppers are divided into four compartments, two opening into each room. One compartment in each room is supplied with a mixture of one part ground bone and three parts of oyster shells, which are bought already broken. The owner thinks that ground fresh bone would be better than that he uses, but he can not conveniently secure the fresh bones for grinding.

The other compartment in each room is filled with a dry mash consisting of four parts of bran, two parts of oats, and one part each of shorts and corn meal. Meat meal is added to this mash, the quantity depending on whether milk is available. Where skim milk is fed, one part of meat meal to twenty-five of the mash is added. When skim milk is not fed the meat meal is added at the rate of one part to ten of mash. The skim milk is fed separately, not in the mash. It has been found unwise to change a pen of laying hens from wet mash to dry; it is all right to feed dry mash to layers and breeders if it has been fed to them since they were chicks. Hens do not eat rolled barley well, but eat ground barley readily.

The dry mash is kept before the hens constantly, a week's supply being put in the hopper at a time. In addition to this, whole mixed grains, one-half wheat, one-fourth oats, and one-fourth corn (less corn in warm weather) are fed once a day, about 3 or 4 o'clock in the afternoon. This mixed grain is thrown into the litter on the floor of the pens, in quantities sufficient to give the hens all they will eat before going to roost—usually a little more than they will eat then, so that when they fly down in the morning there is still left in the straw enough feed to start them to scratching. When they are laying, hens eat more than at other times and should be fed accordingly.

Sharp gravel, for grit, is kept in a box in the outside runways. When skim milk is available, ground bone and meat scraps may be dispensed with; otherwise these nitrogenous materials are indispensable. In addition to the feeds mentioned, some kind of succulent feed is kept constantly before the hens. For this purpose cabbage, kale, mangel-wurzels, carrots, apples, green clover, etc., are utilized. Alfalfa or clover may be cut fine and fed in a box. Alfalfa meal, when available, may be added to the dry mash to advantage.

Another system of feeding is sometimes used with certain pens. It differs from the preceding as follows: The dry mash is omitted; mixed grains, two-thirds oats, one-third wheat, with a little corn in very cold weather, are fed in the litter in early morning; about 4 p. m. a wet mash, similar in composition to the dry mash previously described, is given, in quantity as much as will be eaten up clean before the hens cease feeding.

If the right kind of feed is used a hen that is laying regularly will hardly eat more than she needs. But hens that are not laying, or that are laying at infrequent intervals, can easily be overfed. The feeder must watch carefully and feed each pen of hens according to their condition and egg production. It is a good plan to put in the same pen those that lay about the same number of eggs; the feeding can then be better regulated to suit the needs of the hens.

CLEANING DAY.

The dropping boards (see figs. 6 and 7) are cleaned once a week. These boards are directly beneath the perches and are kept covered with a thin layer of dry dirt and frequently sprinkled with slaked lime. Beginning at one end of the building, a wheelbarrow is pushed through the swinging doors which separate the pens (the doors swing both ways) and is placed directly under the spout (fig. 6, *c*). A hoe is used in removing the droppings.

As previously stated, the litter on the floor is replaced about every ten days, and about twice during the winter the floors are thoroughly cleaned, free use being made of disinfectants if there is the least sign of its being needed. In summer, when the hens are not closely confined to their pens and runs, the litter is not always used, the dirt floors being left bare. In this case the floors are thoroughly cleaned once a month.

MANAGEMENT OF BREEDING HENS.

About one-fourth of the flock of hens is handled separately from the layers, for the production of fertile eggs. About 2,000 of these eggs are incubated on the farm, the remainder being used to supply a growing demand for eggs for hatching. During the summer, as the layers of the previous winter are disposed of, the best are retained for the breeding pens. By September the selection of the most promising pullets for breeders begins. This continues till about December 1, at which time the selected pullets are transferred to the breeding pens, if this has not already been done. The pullets are either transferred to the breeding pens as selected, or, if this is not convenient, they are marked by means of leg bands. The most important points to be looked for in pullets are stamina and early maturity. Those that begin laying early are invariably the best layers. An experienced poultryman can tell in advance when pullets are about to begin laying. At this time they rapidly assume their mature form.

During the breeding season, December to June 1, the breeding hens are confined strictly to their pens and attached runs. At other times they are handled just as the layers are handled. Males are allowed with the hens during the breeding seasons only. About the 1st of June, or when the demand for incubator eggs ceases, the males are removed, those not needed again being sold, the best of the yearlings being placed in separate houses on the range, away from the range of the hens. When the males are away, the hens are all allowed to range as freely as circumstances permit, but are carefully housed at night. Hens soon learn to return to the proper pen at night. Two days confinement in their quarters is sufficient to teach them that.

It is not absolutely necessary to allow hens the freedom of a range; they may be kept in small runs. But they need less feed and require less care when they have good range.

The number of breeding pens of each breed is governed by the demand for fertile eggs. For the last few years four pens of Barred Plymouth Rocks, two each of White Plymouth Rocks, Brown Leghorns, and Black Minorcas, and one of White Wyandottes have been maintained. The demand for eggs of the different breeds varies from year to year, but the Barred Plymouth Rocks usually lead all the others. Eggs sold to breeders are taken only from the carefully selected hens in the breeding pens. If the demand for eggs from the producers of broilers exceeds the supply, males are put with the best pens of layers.

While in the laying pens 30 hens are kept in a pen, in the breeding pens only one-fourth to one-half this number are kept together. Of the largest breeds frequently only 8 are kept in one pen; of the smallest, 12 to 15. About 10 Minorcas constitute a breeding pen. The breeding pens are only about half as large as the laying pens. The runs attached to these pens are 30 by 100 feet, thus giving each hen 200 to 375 square feet of run. Runs of this size can be kept well sodded if given proper attention. Clover is very fine for these runs, and by sowing it in June, when the hens are not confined to the runs, a good growth can be obtained by the time they are confined in December.

SELECTING THE MALES.

Some of the breeding pens contain yearling hens, others pullets. Two-year-old males are preferred for both classes, but this necessitates carrying a large number of males until they are nearly 2 years old before they are used. The plan on this farm is to carry over enough of the cockerels used the preceding winter with the mature hens to have older males for all the pens of pullets, and as many more as convenient. The remainder of the pens of mature hens are supplied with young males hatched early the preceding season. Then these young males, or the best of them, are kept over for the pens of pullets the next season. In this way there is always age in one sex, at least, in each pen. It is thus possible to avoid using males and females from the same parents. It is found safer to breed older birds to their own offspring than to breed together those hatched the same season from the same lot of eggs.

The breeding pens are completely made up early in December and the males put in at once. One week later the testing for fertile eggs begins. If broody hens are at hand one of them is set and the eggs tested the sixth or seventh day. If hens are not available a small incubator is used. Fifty per cent of fertile eggs at the first test is considered satisfactory. The percentage of fertility increases rapidly as the season advances. Plymouth Rock pens that give eggs 50 per cent fertile one week after the males are put in the pens will give 60 to 75 per cent of fertile eggs by January 15. Leghorns and Minorcas test 15 to 25 per cent higher both at the first and at later tests. Some fertile eggs may be obtained two or three days after the males are added. Fertility should reach a maximum in ten days.

If the first test shows low fertility, no eggs are sold for hatching until the difficulty is remedied. To do this, males are changed from pen to pen, or two males, each on alternate days, are placed in a pen. An extra supply of males is kept for this purpose, usually half as many more as there are pens. Careful watch of the pens will reveal whether the hens take kindly to a new male. If they do not a change is made. Strong likes and dislikes appear in chickens as in other bipeds. Two males are sometimes placed in the same pen at the same time, provided they do not fight.

POULTRY PRODUCTS MARKETED.

Three classes of eggs are sold. First, by far the larger proportion of the eggs go to the regular trade. About half of these were for some years contracted for by the year at 25 cents a dozen. At present all these eggs are sold at market prices, as this pays better at prices that have prevailed for the past few years.

The choicest eggs from the breeding pens are sold in sittings of 13. Although sold as 13 per sitting, 15 are frequently put in, on the theory that a satisfied customer is worth something by way of holding and extending trade. Nearly all of these eggs go to farmers; a few to fanciers who need this vigorous blood to remedy the defects arising from their system of breeding for feathers.

The remaining eggs from the breeding pens are sold in incubator clutches of 50 to 300 or more. The market for this class of eggs extends from late December to the last of May.

Three classes of chicks are sold: (1) Culls and discarded male chicks, which are fattened and sold as soon as the trade will take them, usually at 25 to 50 cents each. (2) Hens over a year old, except those wanted as breeders; some of these are sold to farmers as breeders, and the remainder go as meat. (3) After the first year a few young cocks are sold for breeding purposes.

INCOME FROM POULTRY.

For the year 1906 the income from poultry on this farm was as follows:

Income from sales of poultry and eggs for 1906.

Eggs:	
6,090 dozen to the trade, at 25 cents	$1,522
7,600 eggs for hatching, at 7 cents each	532
Poultry	300
Total	2,354

WORK STOCK.

The work stock on this farm consists of a team of horses and a team of brood mares. One or two colts are raised yearly. In winter these are fed timothy hay and sheaf oats along with some carrots and ruta-bagas. In summer they are fed mostly soiling crops, clover and peas and oats being used. At night they are turned out into a small pasture. When a team is doing heavy work, in addition to the above feeds each animal receives about 8 quarts a day of some kind of grain.

CONCLUDING REMARKS.

Unfortunately the writer is unable to give the expenses of this farm. Estimates could be given, but they would be of little more value than knowledge already in the possession of every intelligent farmer. The Office of Farm Management is now conducting extensive and careful investigations concerning the cost of everything on a large number of farms. When these investigations are completed, something more than estimates of cost can be given for such farms as the one here described.

Leaving aside the question of profits, here is a farm that is well-nigh ideal. The farm home is all that could be wished, except that school facilities, 12 miles in the country, in the foothills of the Olympics, have not been all that could be desired. The library is well supplied with agricultural journals, to nearly all of which the farmer and his estimable wife are valued contributors. For many years the owner of this farm was president of the State Dairymen's Association, and he is a prominent farmers' institute worker in more than one State. One son is employed as a scientist by the United States Department of Agriculture; another will be a farmer; the third has not yet selected a vocation, but likes farming. One daughter is teaching; one looks after the poultry; the third keeps the books. All of them are well grounded in domestic economy.

Here is a farmer who has not lived in vain. He has done his duty to his country, and it is fitting that the results of his labors should thus become the common property of his fellow-farmers.

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FARMERS' BULLETIN 356.

PEANUTS.

BY

W. R. BEATTIE,

Assistant Horticulturist, Bureau of Plant Industry.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 19, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Peanuts," by Mr. W. R. Beattie, Assistant Horticulturist, and recommend that it be published as a Farmers' Bulletin to supersede the former publication of this title issued as Bulletin No. 25 of the same series. During the past ten or twelve years the methods of production and the uses of peanuts have so changed and increased as to call for the issuance of a new bulletin.

The peanut is rapidly becoming an important farm crop throughout the Southern States. Its vines are valuable as forage and the peas that are not marketable can be used for feeding purposes. Throughout the boll-weevil district of the cotton belt the peanut is rapidly becoming of importance as a money crop, and special oil-producing varieties will doubtless assist in keeping the oil mills of the Southern States supplied with raw materials.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 7
Soil and climatic requirements of the peanut 8
Preparation of the soil 10
  Time for plowing 10
  Depth of plowing 10
  Preparation for planting 10
Fertilizers and preparatory crops 11
  Cropping system and green manures 11
  The use of stable manure 12
  Commercial fertilizers 12
  Importance of lime in the soil 13
  The peanut as a nitrogen gatherer 13
The seed and its selection 13
  Importance of planting good seed 13
  Improvement by selection 15
  Planting shelled or whole seed 15
Time and methods of planting 15
  Distance to plant 15
  Quantity of seed required 16
  Depth to cover the seed 16
  Tools and methods of planting 17
General cultivation 17
  Method of cultivation 17
  Tools adapted to cultivating peanuts 18
Harvesting 19
  Proper time for digging the crop 19
  Methods employed for lifting the plants 19
  Curing process and care of crop after digging 20
Picking and cleaning 23
  Picking by hand 23
  Use of machines for picking 24
  Care of peanuts after picking 25
  Preparation of peanuts for market 26
  Methods of cleaning peanuts in the factory 26
  Cleaned vines as stock feed 27
Varieties of peanuts 27
  Descriptions of varieties 29
    Virginia Bunch 29
    Virginia Runner 29
    North Carolina 29
    Spanish 29
    Tennessee Red 30
    Dixie Giant 30
  Varieties for marketing 30
  Varieties for stock feeding 31

Page.
The uses of the peanut 31
  Important uses for human food 31
  The uses of peanut by-products as foods for live stock 33
  Possibilities in the manufacture of peanut oil 34
The importance of the peanut as a farm crop 35
  The value of peanut hay for feeding purposes 36
  The value of the entire peanut plant as forage 36
  The use of peanuts for fattening hogs 37
  Methods of handling and curing peanuts for forage 37
Insects injurious to the peanut 38
Diseases of the peanut 38
Conclusions 39

ILLUSTRATIONS.

Page.
FIG. 1. Map of the United States, showing the area adapted to the production of peanuts 9
2. Disk plow adapted for fitting land 10
3. Harrow adapted for smoothing and pulverizing land 11
4. Roots of peanut vine, showing the value of this plant as a nitrogen gatherer 14
5. Machine for marking land and sowing fertilizer 16
6. One-horse peanut planter 17
7. One-horse cultivator 18
8. Plow type of peanut digger 19
9. Machine potato digger in use in digging peanuts 20
10. Machine potato digger adapted for harvesting peanuts 21
11. Stakes around which shocks of peanut vines are to be built 22
12. Laborer building a shock of peanut vines, showing method used 23
13. Peanut shocks placed close together near farmyard 24
14. Picking peanuts from the vines by hand 25
15. An improved type of peanut-picking machine in operation 26
16. Commercial types of peanuts 28
17. Virginia Bunch type of peanut 29
18. Spanish type of peanut 30
19. Peanuts growing in the alleys between rows of corn 35
20. Disease appearing upon the leaves of the peanut 39

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PEANUTS.

INTRODUCTION.

It is not definitely known when and where the peanut was first cultivated. Several allied species of plants are natives of Brazil, and there is every indication that the common peanut originally came from tropical America. Peanuts were introduced into the United States during the earlier days of colonization, but did not become of commercial importance until about 1870. From that time until 1897 the growth of the peanut industry was gradual, but a great increase in the production and use of peanuts has taken place during the last eight or ten years.

Botanically the peanut belongs to the same group of plants as do the beans and peas, but it possesses the character of maturing its fruit or nut beneath the surface of the soil rather than above ground, as do most other leguminous plants. The technical name of the peanut is *Arachis hypogea*, the name indicating the characteristic habit of the plant to mature its fruits underground. The peanut is known under the local names of "goober," "goober pea," "pindar," "ground pea," and "groundnut." The names "goober" and "goober pea" are more properly applied to an allied species having no true stem and only one pea in each pod which has been introduced and is frequently found growing wild in the Gulf Coast States. Properly speaking, the peanut is a pea rather than a nut, the term "nut" having been added on account of its flavor, which is similar to that of many of the true nuts.

The small yellow flowers of the peanut are borne in the little pocket where the leaves are attached to the stems, and as soon as pollination has taken place the visible portion of the flower fades and falls, after which the short, thick stem that supports the lower portion of the flower elongates and the sharp-pointed ovary is thrust downward into the soil, where the pod develops. Should the ovary fail to reach or penetrate the soil no pod will be formed.

The value of the commercial peanut crop of the United States for the year 1908 was estimated at $12,000,000. During recent years the area of production of peanuts has greatly increased, especially throughout the warmer parts of the country. The value of the peanut, both as a money crop and for feeding on the farm, renders it especially desirable as a part of the rotation wherever conditions suitable to its development exist.

Most persons think of the peanut as it appears for sale at the news and fruit stands, but during recent years many new lines of consumption have been found. In addition to the great quantity of peanuts sold in the shell each year, thousands of bushels are shelled for use in the manufacture of confections and food products.

It is the purpose of this bulletin to give full cultural directions for growing this crop, together with some of the uses of the peanut. The peanut is well adapted for use as a part of the cropping system in the Southern States, especially on the cotton and tobacco lands. Soils that will not produce more than one-fourth of a bale of cotton to the acre can be made to yield a fair crop of peanuts at a very low cost for growing. Comparatively few persons realize the value of peanuts when used as a farm crop, especially when the product is fed to live stock on the farm and eventually returned to the soil in the form of manure.

SOIL AND CLIMATIC REQUIREMENTS OF THE PEANUT.

The soil best suited to the peanut is one of a sandy, loamy nature, preferably light or grayish in color rather than dark. Soils that are dark and those carrying a considerable percentage of iron or other mineral are likely to stain the shells of the peanuts, thus rendering them less desirable for the trade. For agricultural purposes, however, the staining of the shells is of little consequence, as it does not materially injure them for stock feeding. In fact, soils that contain considerable clay and lime or are loamy in character produce heavier nuts and sometimes greater yields than do lighter soils. As a rule the peanut does best on a sandy loam with a well-drained clay subsoil, but the crop may be grown under a wide range of soil conditions. Soils that become hard or compact are not adapted to peanut growing, owing to the inability of the pod stems or " pegs " to penetrate the surface.

Soils that are poorly drained or sour are not suited to the peanut. The ideal soil consists of a sandy loam containing a reasonable amount of humus, or vegetable matter, together with an abundance of lime. A soil having a suitable mechanical consistency is the first essential. Soils lacking in fertility can be improved by a proper cropping system or by the judicious use of manures.

The cultivation of the peanut for commercial purposes has until recently been confined chiefly to areas in Virginia, Tennessee, the

Carolinas, and Georgia. During recent years the industry has become established throughout the South Atlantic States and westward to and including California. The territory indicated by the dark portion of the map shown as figure 1 is for the most part adapted to the production of peanuts for agricultural purposes; over a large part of this section a good grade of marketable nuts can be grown. This area, it will be observed, is one within which the frost-free season is comparatively long, and much of the territory has a soil containing a large percentage of sand or alluvial matter, making it easily cultivated and well adapted to the peculiar habits of the peanut plant. There are undoubtedly many sections outside of the area indicated by the map (fig. 1) that can be profitably devoted to the production of peanuts for stock food, and a few regions where they can be grown commercially.

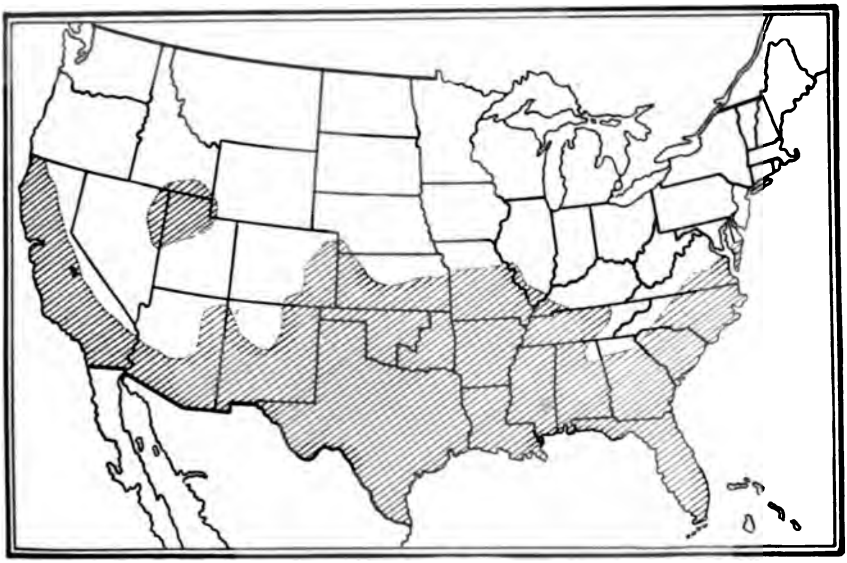

FIG. 1.—Map of the United States, showing the area adapted to the production of peanuts.

The climatic requirements of the peanut are a long season without frost, a comparatively light rainfall during the growing period, abundant sunshine, and a high temperature. The peanut is slightly more susceptible to injury from frost than the common bunch bean and requires a somewhat longer season for its development. The Spanish peanut will mature in ninety days under the most favorable conditions, but one hundred and ten to one hundred and twenty days should be allowed. The large-podded varieties require a longer period for best results.

PREPARATION OF THE SOIL.

Time for plowing.—The time for plowing the land to be planted to peanuts will depend somewhat upon its previous treatment. If the land has been in corn the season before and a crop of crimson clover was sown at the time the corn was laid by, it will be desirable to plow the land just before the clover blooms in order to get the greatest benefit from it as a green manure. If the land is in sod it will be desirable to break it during autumn or winter. If there is no crop on the land the plowing need only be done in time for planting, or rather but a short time before planting, in order to allow the soil to settle. Where a crop of crimson clover is turned under, the soil should be thoroughly harrowed and rolled in order to obtain a compact seed bed and to retain moisture.

Depth of plowing.—The depth of plowing will depend somewhat upon the character and depth of the surface soil. On sandy soils that are underlaid by a clay subsoil it would be unwise to bring a very great quantity of the subsoil to the surface. If the surface soil is not of sufficient depth, it should be increased by plowing a very little deeper each year until a sufficient depth is reached. As a general rule the depth of plowing for peanuts should not be quite so great as that for corn in the same locality. From 5 to 7 inches of loose soil will be sufficient for the growing of all varieties of peanuts. Subsoiling may prove beneficial on soils having insufficient drainage.

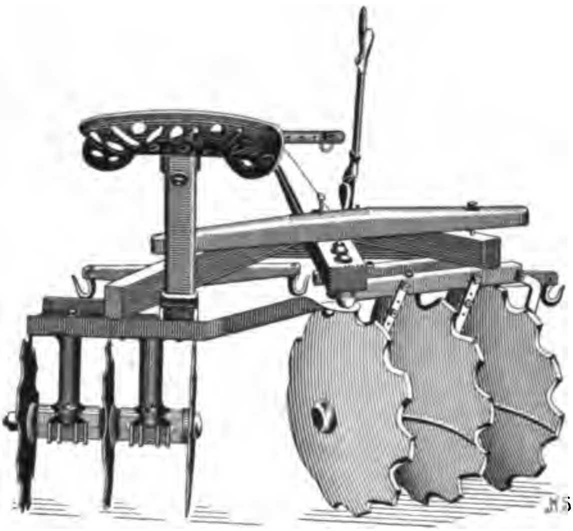
FIG. 2.—Disk plow adapted for fitting land.

Preparation for planting.—When the land is plowed but a short time before planting it should be harrowed within a few hours after plowing, in order to prevent loss of moisture. On loose, sandy soils that are reasonably free from weeds or grass it is often possible to dispense with the regular plowing and cut the land with a disk harrow or disk plow. A tool that is especially adapted for this purpose is shown in figure 2. This implement both cuts and turns the soil, leaving it in fine condition, so that it is readily prepared for planting.

Where plowing is necessary in order to turn under sod, clover, or weeds a tool of the type shown in figure 3 is desirable for smoothing and pulverizing the soil afterwards. This harrow is superior to the ordinary smoothing harrow in that it turns, crushes, and levels the soil in one operation. By means of a lever the cutting blades can be set to any depth, and the weight of a boy or light man upon the seat is sufficient to secure good work. If the soil is very loose it may be necessary to roll or drag thoroughly before planting.

Under ordinary circumstances level culture should be practiced, but where the drainage is poor it may be advisable to throw up slight ridges upon which to plant peanuts; this is especially desirable during a season of excessive rainfall. When ready for planting, the soil should be in the same general condition as that prepared for a crop of snap or bunch beans. Thorough preparation of the soil is profitable for all crops, and especially for peanuts. If the soil can be harrowed once a week for three or four weeks before planting, most of the weeds that would otherwise injure the crop will be destroyed.

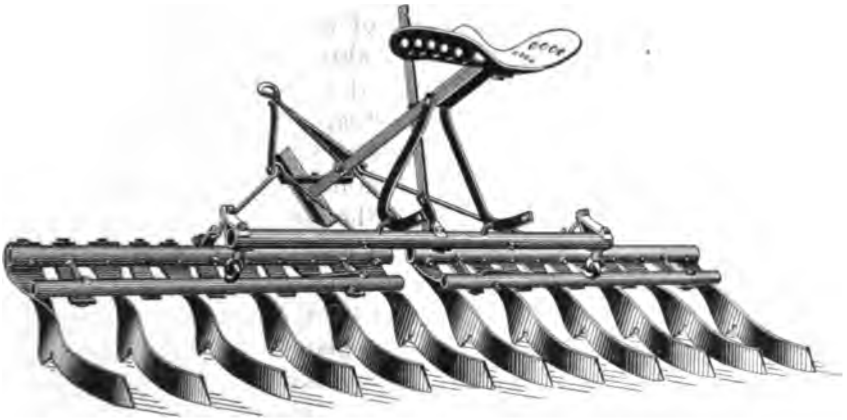

FIG. 3.—Harrow adapted for smoothing and pulverizing land.

FERTILIZERS AND PREPARATORY CROPS.

Cropping system and green manures.—Peanuts should be grown in rotation with other crops rather than as a specialty. The cropping system will depend somewhat upon the area of other crops grown, but the arrangement should be such that the land will be planted to peanuts one year in each three or four. A good rotation is corn or cotton the first year with cowpeas planted between the rows at the time of the last cultivation; the next season plow under the remains of the cowpeas and plant the land to peanuts; as soon as the peanuts are harvested sow the land with rye and use as a winter pasture; plow under the rye during the springtime and plant cowpeas, using the peas as a hog pasture during the autumn; then return to corn or cotton the following year.

Another plan would be to devote the land one year to sweet potatoes instead of cowpeas, or to a crop of early Irish potatoes followed by cowpeas or crimson clover. In this rotation stable manure should be applied to the crop of corn or cotton, and the commercial fertilizers with the peanut and potato crops. Peanuts should invariably follow some well-cultivated crop which has been kept free from weeds.

The use of stable manure.—Stable or barnyard manure should not be used as a fertilizer the same year that the land is planted to peanuts owing to the great number of weed seeds that are contained in the manure. The use of manure also has a tendency to cause the plants to produce abnormal tops and a large percentage of poorly filled pods, known to the trade as "saps" or "pops." The proper time for applying stable manure is with the crop grown the previous season, thus giving it time to become incorporated with the soil and reduced to the proper condition for the peanut crop.

Commercial fertilizers.—The peanut responds to the use of commercial fertilizers. However, a reasonable amount of humus in the soil is essential. If properly handled, the peanut crop is not exhaustive of soil fertility; in fact, the plant is a great nitrogen gatherer, as may be observed by the large number of nodules upon the roots. On the other hand, if the entire plant, including the root, is removed and no part returned to the soil the peanut becomes almost as exhaustive of soil fertility as cotton or corn. By feeding the straw and other refuse from the crop to cattle, hogs, and work animals and applying the manure thus obtained to the land the fertility may be retained or even increased.

On soils that are adapted to the production of peanuts it will not be necessary to employ commercial fertilizers in large quantities. Soils abundantly supplied with nitrogenous matter will, especially during a rainy season, produce an overgrowth of vine and poorly filled pods.

A commercial fertilizer adapted to the production of either Irish or sweet potatoes is as a rule suited for the growing of peanuts. A mixture which contains from 2 to 4 per cent of available nitrogen, 5 to 7 per cent of available phosphoric acid, and 6 to 10 per cent of potash is desirable; this should be applied at the rate of from 200 to

1,000 pounds to the acre, according to the needs of the land. Most growers follow the practice of scattering the fertilizer in a narrow strip where the row is to be planted, but for the general good of the land it is a better plan to sow or drill the fertilizer broadcast. In all cases it is important that the fertilizer be thoroughly mixed with the soil.

Importance of lime in the soil.—In order to insure the proper filling and ripening of the pods, peanuts require an abundance of lime in the soil. Where the soil is of a calcareous nature, containing limestone, shells, or lime in its more active form, it may not be necessary to make a regular application, but on soils that are deficient in lime or inclined to be in the least sour, from 1,000 to 2,000 pounds of fresh-burned lime should be applied to an acre every four or five years. The lime should not be put on at the same time as the commercial fertilizers, but rather during the previous autumn, or at the time of plowing the land. Wood ashes are desirable as a fertilizer for peanuts, as they contain both potash and lime. Unleached wood ashes may be applied broadcast at the rate of 1,000 to 1,200 pounds, 25 to 30 bushels, to the acre.

The presence on the land of certain weeds, such as the common sorrel and the sedges (which have three-cornered stems), indicates sourness and insufficient drainage; to correct this an application of lime will be necessary in addition to ditching or tile draining. Lime should be used on land that is to be planted to peanuts, unless it is definitely known that there is an abundance of it already present.

The peanut as a nitrogen gatherer.—The peanut plant, in common with other leguminous plants, has the power of collecting the free nitrogen of the atmosphere and storing it in little nodules upon its roots. For this reason the peanut is one of the more desirable of our soil-renovating and soil-improving plants. It should be borne in mind, however, that in order to benefit the soil the nitrogen so gathered should not be removed, but that the main portion of the roots should be left in the soil. Figure 4 shows the root of a peanut plant which is abundantly covered with the nitrogen-storing nodules.

THE SEED AND ITS SELECTION.

Importance of planting good seed.—A good grade of seed is just as important with the peanut as with corn, wheat, or any other crop. There is perhaps no other farm crop except corn that is so greatly influenced by the character of seed planted as the peanut. The very best peanuts of the previous season's crop should be selected for seed, and of these only the most mature and perfect peas should be used. Seed should be saved only from well-ripened and mature plants and should be properly cured and kept dry during the winter months.

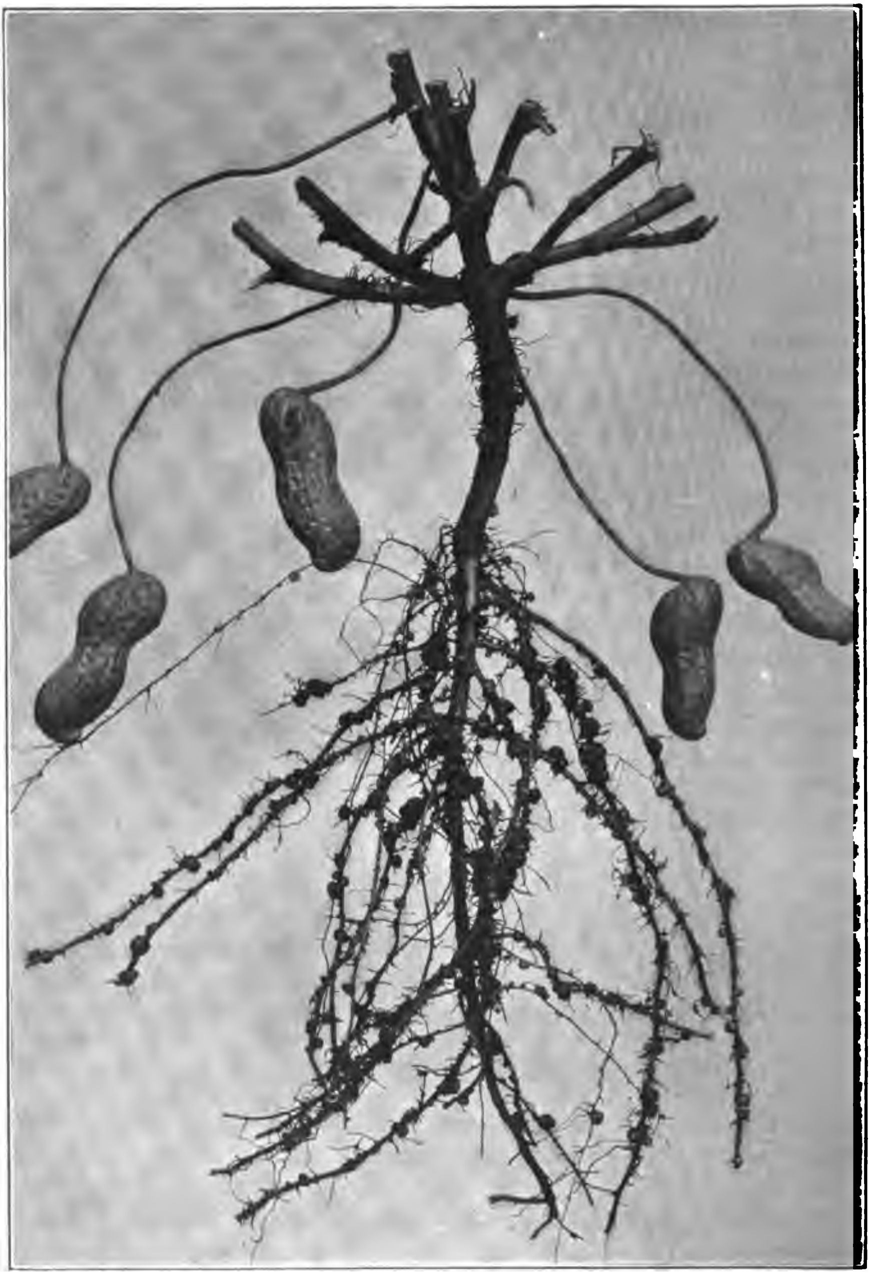

FIG. 4.—Roots of peanut vine, showing the value of this plant as a nitrogen gatherer. The nodules on the roots are formed by the bacteria which collect the nitrogen.

Good seed produces a more even stand of plants, which in itself returns a greater yield.

Improvement by selection.—The seed should not only be selected from plants that are mature, but from those producing a large number of mature pods as well. By doubling the number of well-filled pods on each plant the yield for each acre will also be doubled. Many millions of bushels have been added to the corn crop of the country simply through the selection and improvement of seed.

What has been done with corn is possible with the peanut, and where we now have an average yield of 34 bushels to the acre it is reasonable to expect this to be increased to 50 or 60 bushels through seed and cultural improvements.

Planting shelled or whole seed.—In planting the large-pod varieties it is desirable for several reasons that the seed be shelled. In the first place the planting machines now in general use are adapted to handling the shelled seed only. Second, when planting whole pods there is always a doubt regarding their being well filled, and a poor stand may result. Third, pods containing two or more seeds will produce more than one plant in a hill, causing a waste of seed and a crowding together of the plants. Fourth, whole seed is slower in germinating than shelled seed. With the Spanish variety the case is quite different, as several of the machines will handle the whole nuts, the pods are invariably filled, the crowding together of the plants is no great disadvantage, and the few days extra time required for germination is of little consequence.

Virginia nuts intended for seed should always be shelled by hand, but the Spanish are sometimes shelled by machinery, although their germination is invariably injured when so handled. Many growers of the Spanish peanut practice soaking the unshelled nuts in water previous to planting. Soaking for a few hours will hasten germination, but if for any reason the seed can not be planted immediately it will be lost. Shelled seed should never be soaked before planting.

TIME AND METHODS OF PLANTING.

The time for planting peanuts is in the spring after the soil has become thoroughly warm. In order to secure a good stand, the seed should not be put in the ground until there is sufficient warmth to germinate it quickly. As a rule peanuts should be planted a trifle later than corn and beans. The Spanish variety may be planted somewhat later than the Virginia type, as it requires less time to complete its growth.

Distance to plant.—A common distance between rows is 36 inches, but this varies somewhat according to the soil and variety. For the Virginia Runner variety on good soil the distance between rows should be at least 36 inches, and 12 inches between the plants in the rows. Virginia Bunch peanuts may be in rows as close together as 30 inches, and 7 to 9 inches apart in the rows. The Spanish and Tennessee Red varieties are planted in rows from 28 to 36 inches apart and 7 to 9 inches apart in the rows according to the fertility of the soil. On rich soils, where the spread of vine will be great, the maximum distance between rows as well as between plants in the row should be allowed.

Quantity of seed required.—The quantity of seed peanuts required to plant an acre will depend somewhat upon the distances of planting. As a rule one-half bushel of shelled Virginia peas will plant an acre. One and one-half pecks of shelled Spanish peanuts, or 2 bushels in the pods, are required for an acre. The greater the care exercised in planting, the smaller will be the waste of seed, and economy is quite an object when planting specially selected or high-priced seed.

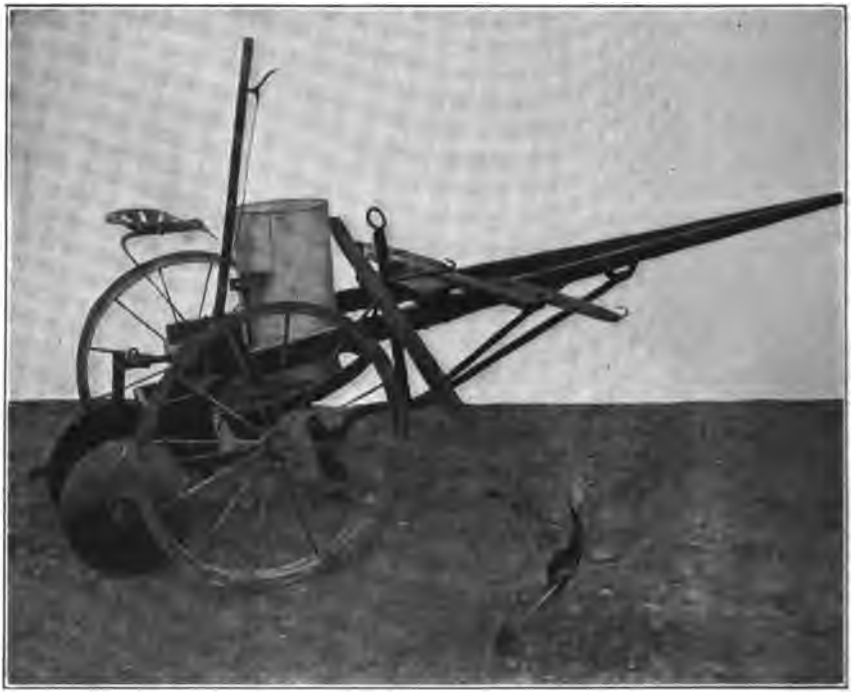

FIG. 5.—Machine for marking land and sowing fertilizer.

Depth to cover the seed.—The depth to which the seed should be covered will depend somewhat upon the character of the soil. On heavy soils three-fourths inch to 1¼ inches will be sufficient, while on light sandy soils 1½ to 2 inches may not be too deep.

Tools and methods of planting.—Peanuts are generally planted in rows that are cultivated in one direction only. Some growers follow the practice of first marking the land with an implement similar to the ordinary corn marker. Others open a furrow with a one-horse plow, then after the fertilizer has been distributed in the furrow the plow is again used and a slight ridge thrown up. There is now on the market a tool of the type shown in figure 5, which sows the fertilizer, throws up a slight ridge, and at the same time indicates the position of the next row. If desired, this machine can be supplied with a seeding device, which will complete the planting at one operation.

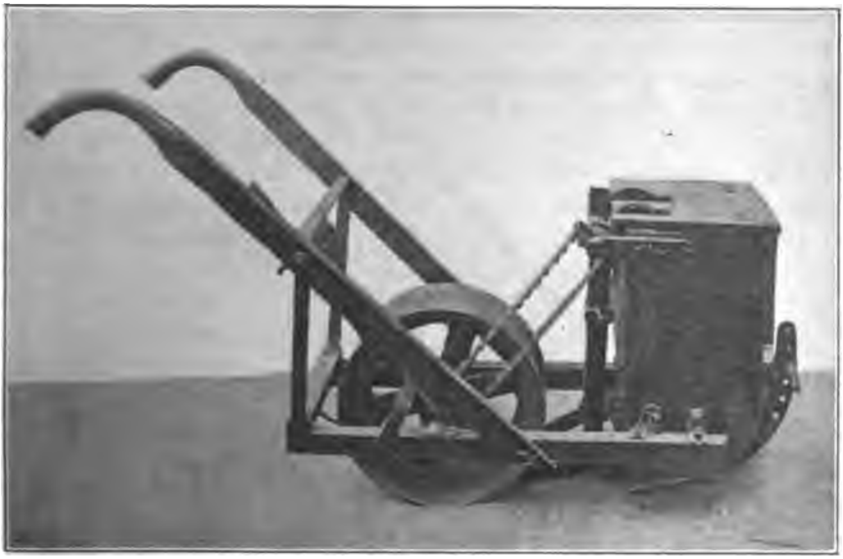

FIG. 6.—One-horse peanut planter.

The greater portion of the peanut crop is planted with the one-horse planters of the type shown in figure 6. These machines are similar in many respects to a cotton planter; in fact, a cotton planter may be adapted to planting either the whole Spanish or the shelled Virginia peanuts with very little trouble or expense. The ordinary peanut planter costs in the neighborhood of $15 in most localities.

GENERAL CULTIVATION.

Method of cultivation.—Cultivation of the peanut crop should begin as soon as the rows can be followed and continue until the vines begin to occupy the ground. The work of cultivation should be pursued very much the same as for corn, beans, and all similar crops. Frequent shallow cultivation that will keep the soil loose and prevent the loss of moisture is essential. Shortly after rains the surface soil should be stirred and during dry weather a dust mulch maintained. After the first cultivation it will be desirable to work the soil toward the rows to provide a bed of loose earth in which the pods may form.

After the peanuts begin to " peg," or form pods, they should not be disturbed or given further cultivation. The old idea that the blossoms of the peanut must be covered is erroneous, although growers frequently allow considerable soil to be thrown over the vines during the final cultivation. For the last cultivation it is a common practice to employ a tool that will both throw the soil toward the rows and leave a furrow in the middle of the alley to carry off water during heavy rains.

Common crab-grass is one of the most troublesome weeds of the peanut fields and it is often necessary to resort to hand hoeing in order to keep this and other weeds out of the rows. If the crop is kept well worked with horse tools, very little hand labor will be required.

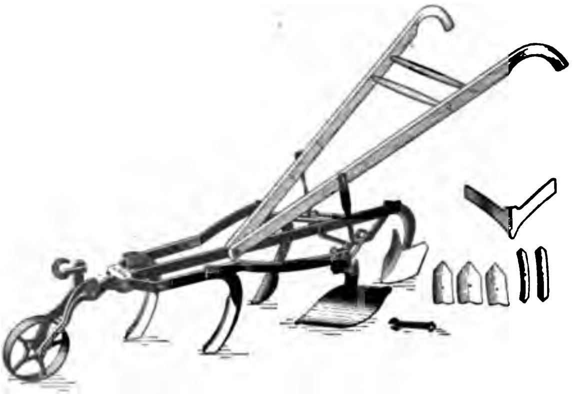

FIG. 7.—One-horse cultivator.

Tools adapted to cultivating peanuts.—Most implements that are adapted to the cultivation of corn or cotton will be found suitable for handling the peanut crop. For the first two or three cultivations a spring-tooth riding cultivator is desirable, while for the later workings the same implement can be used by changing the spring teeth for regular cultivator shovels. For one-horse cultivation the ordinary cotton sweep is frequently used, but the form of cultivator shown in figure 7 will do more efficient work. This implement is provided with several styles of narrow and broad shovels, sweeps, and hillers, making it adaptable to a great many changes and suited to a wide range of conditions.

Some growers follow the practice of running a light roller over the plants after the final cultivation, the object being to flatten the stems upon the ground in order that the little pods forming on the extremities of the stems may reach the soil. This practice may increase the yield, but it will also increase the percentage of " saps," or unfilled pods, and it is doubtful if anything is gained by the practice.

HARVESTING.

Proper time for digging the crop.—No fixed rule can be given by which to determine when to remove the peanut crop from the ground, and each grower must be his own judge in the matter. In general practice the growers aim to dig before the first frosts, in order that the peanut vines may have greater value for stock food. To the southward, where frosts do not appear until quite late, the vines assume a yellowish appearance during the latter part of the season, which indicates the ripening of the peas. If digging is deferred too long, the first-formed peas are likely to burst their shells and start growing; this is especially true if there is a period of rainy weather late in the season. The aim should be to dig at the time the vines have upon them the greatest number of mature peas. Where a large acreage is grown it will be necessary to begin harvesting as soon as the earliest peas are ready, in order to complete the work before unfavorable weather sets in.

Methods employed for lifting the plants.—Under ordinary circumstances the peanut vines are plowed from the ground with a one-horse turning plow and afterwards separated from the soil by hand. Many growers employ either a two-horse plow similar to that frequently used for digging potatoes or a turning plow with the mold-board removed to prevent a furrow being turned. A digger of this type is shown in figure 8. Behind the digger or plow a gang of workmen shake the vines and peas free from the soil and throw them in small bunches. In this manner a team and driver accompanied by eight or ten hands will dig from 5 to 7 acres a day at a cost of about $2.50 an acre.

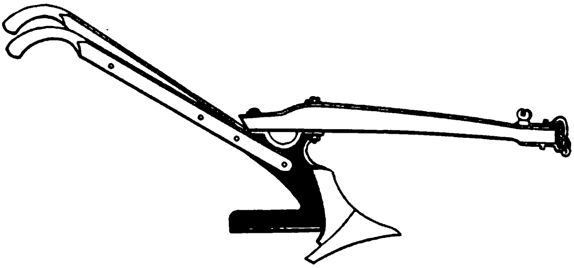

FIG. 8.—Plow type of peanut digger.

It has been found by experiment that the regular machine potato digger drawn by two or three horses driven by one man will dig from 8 to 12 acres a day and do the work in a much cleaner and better manner than the old plow and hand method. This machine not only removes the peanuts from the ground in a more perfect manner but also shakes off the soil and leaves the vines lying loosely upon the surface of the ground. By the hand method a great many pods become detached from the vines, while with the machine potato digger scarcely a pod is lost. A machine of this character in operation is shown in figure. 9. Another machine slightly different in design is shown in figure 10.

The cost of a machine potato digger is about $100, but with proper care it should last many years; besides, one machine would do the work for two or more growers. Almost any of the machine potato diggers may be used for digging peanuts, but where the vines of the "runner" peas are exceptionally heavy there may be some difficulty in getting the vines through the machine. This difficulty may be overcome by providing disks or cutters to cut away the ends of the vines in front of the machine.

Special machines are now being offered which are intended to dig, clean, and bunch the peanuts. By setting any of these machines to the proper depth it is possible to sever the main root of the peanut just below where the pods are formed and thus leave considerable of the accumulated nitrogen in the soil. It is estimated that the nitrogen left in the soil by this system has a fertilizing value of from $3 to $4 an acre.

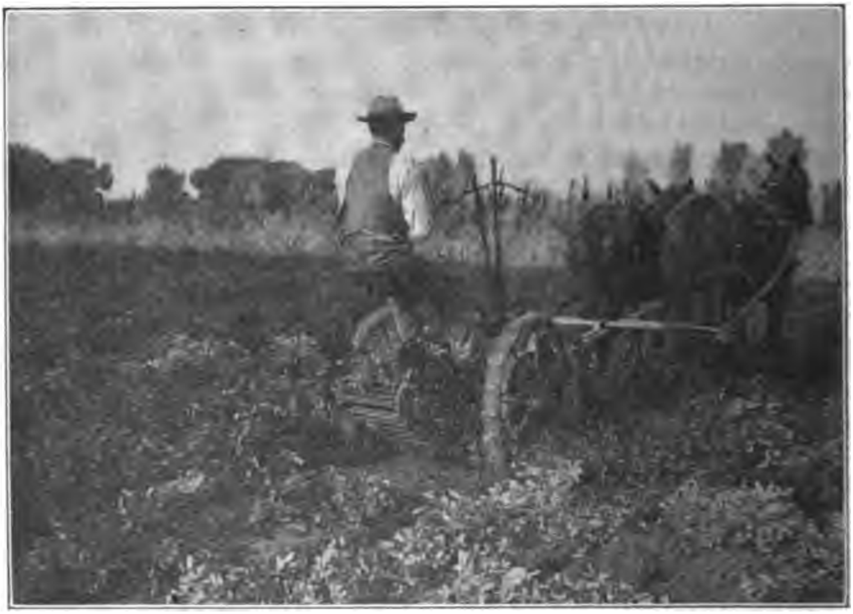

FIG. 9.—Machine potato digger in use in digging peanuts.

Curing process and care of crop after digging.—After the peanut vines are loosened from the soil they are allowed to lie either spread upon the ground or in small bunches for three or four hours, and are then placed in small stacks around a central stake to cure. If the peas are allowed to lie exposed to the weather for any length of time after digging, the pods become discolored and lose in weight.

A better grade of peanut hay will be secured if the vines are placed in the small stacks as soon as the leaves and stems are thoroughly free from dew or other surface moisture. Most growers follow the practice of putting the peas in shock the same day they are removed from the soil, or those dug during the morning are stacked in the afternoon and those dug later in the day are stacked the following morning as soon as they are free from dew; however, any dew or rain will discolor the pods.

The essentials in caring for the crop during the curing period are that the peanuts be kept in small stacks, given an abundance of air, and protected from both the weather and injury from animals. Owing to the fleshy nature of the stems they cure quite slowly and are liable to mildew if placed in large lots.

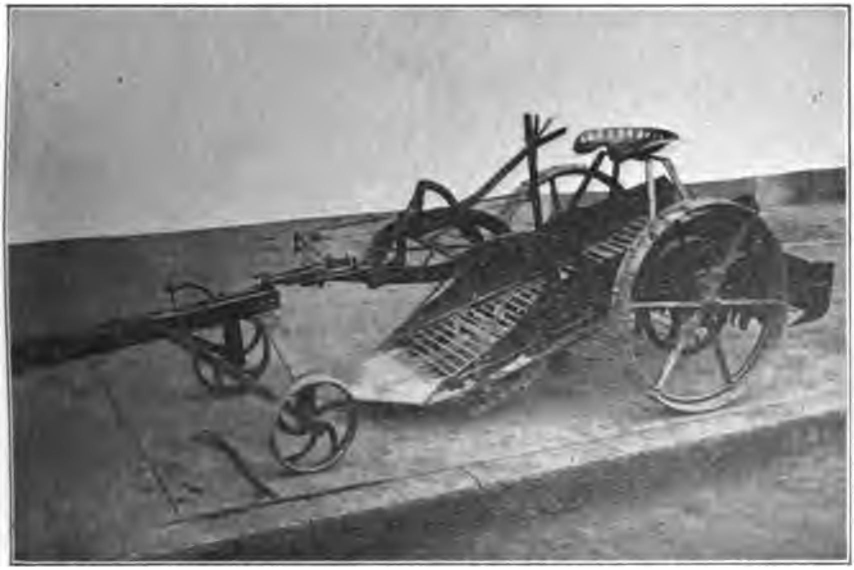

FIG. 10.—Machine potato digger adapted for harvesting peanuts.

In order to produce a good grade of peanuts for the market it is necessary to cure them in small stacks built around a central stake or pole. The supply of stakes should be ready in advance and may be kept for use from year to year. These stakes should consist of split or round poles about 3 or 4 inches in diameter, 7 feet in length, and sharpened at both ends. For setting the stakes in the ground a pointed bar of iron or a crowbar with which to make the holes is necessary. The stakes should be set in the ground to a depth of 12 to 18 inches and well tamped to make them firm and solid.

Before starting the shock one or two pieces of lath are nailed across the stake a few inches from the ground, in order to prevent the peanuts coming in direct contact with the soil. In starting to build the shock a few vines are laid across the pieces of lath and the shock then built up by successive layers of vines, the pods being kept well to the center and the tops to the outside. The stems should have sufficient outward slope to shed water. Occasionally a few vines should be hung around the stake in order to tie the shock together. By this method the pods will be near the center and around the pole, where there is an upward circulation of air and general protection. When the shock has reached the desired height, a bunch of vines is rolled together and pressed down over the point of the stake to form a top, or a little grass or weeds may be used for this purpose.

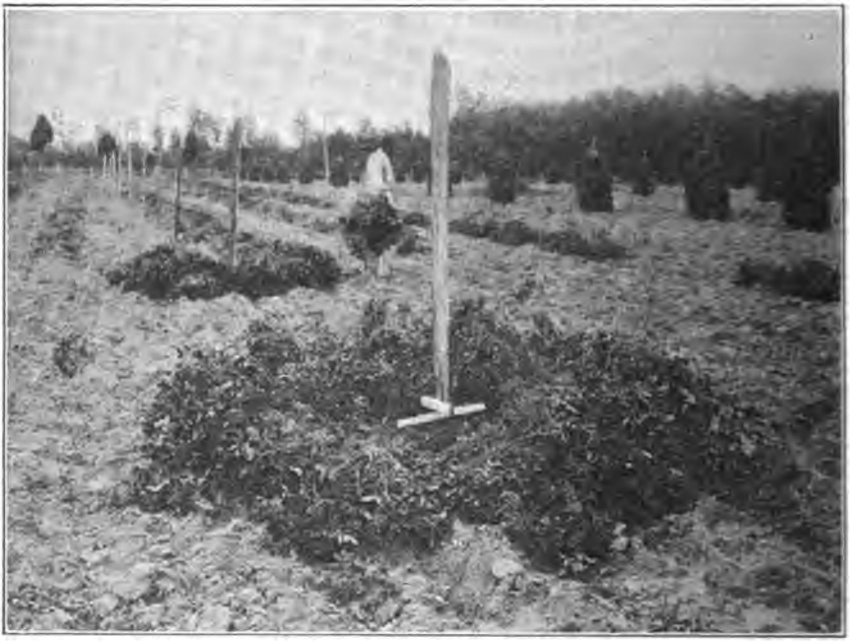

FIG. 11.—Stakes around which shocks of peanut vines are to be built.

The majority of growers follow the practice of placing the shocks singly in rows in the field where the crop is grown; others arrange them in groups of from four to ten, while some growers haul the crop to a stacking yard, where the shocks are built closely together. Figure 11 shows stakes set in the ground and crosspieces nailed on. Figure 12 shows a shock during construction, as well as completed shocks in the background. Figure 13 shows the method of stacking closely together.

Storage in barns is not advisable when curing peanuts for market, but where the entire plant is fed to stock the crop may be handled in much the same manner as cowpeas, velvet beans, or a heavy growth of clover.

PICKING AND CLEANING.

Peanuts for market should be cured in the shock at least three or four weeks before picking. If the weather is dry and windy immediately after harvesting, the curing process will be quite rapid, but should the weather conditions be unfavorable during this period the pods will ripen more slowly. Too rapid curing is not desirable, as the pods are likely to shrivel and discolor. Peanuts should not be picked from the vines until the pods have become dry and the peas firm and nutty, with the immature ones more or less shrunken. As a rule very little is to be gained by early marketing, and a better grade of peanuts will be secured if picking is deferred until late autumn. If the pods are not well protected in stacking, many will be destroyed by the common blackbird. In some sections it is necessary to pick as early as possible to prevent heavy loss from the ravages of field mice and rats while the peanuts are in the shock.

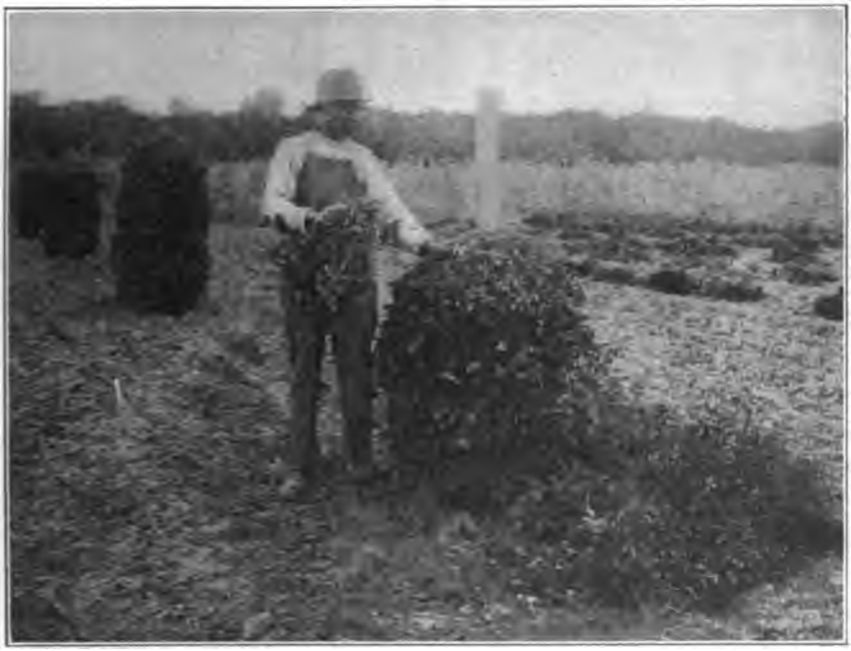

FIG. 12.—Laborer building a shock of peanut vines, showing method used. Completed shocks in background.

If peanuts are not well stacked the pods are liable to become discolored by the heavy fogs and driving rains of late autumn. The stacks should not be opened or the vines handled during wet weather.

Picking by hand.—The standard of excellence in the peanut markets is always based upon hand-picked stock. Peanuts that are picked by hand now bring a higher price than those picked by machinery, but with the present scarcity of labor and rapid improvement in peanut-picking machinery the time will soon come when a uniform price will be paid for a given quality of peas regardless of how the picking is done.

Figure 14 shows a characteristic group of pickers at work in a peanut field of southern Virginia. Hand picking is at best a dusty and laborious task and is usually done by the women and children. Where the vines are well set with pods a good picker will handle from 8 to 12 bushels a day. The price paid per bushel for picking varies from 8 to 20 cents, according to the quality and variety of peanut, but 10 cents is the ruling price paid for picking Virginias.

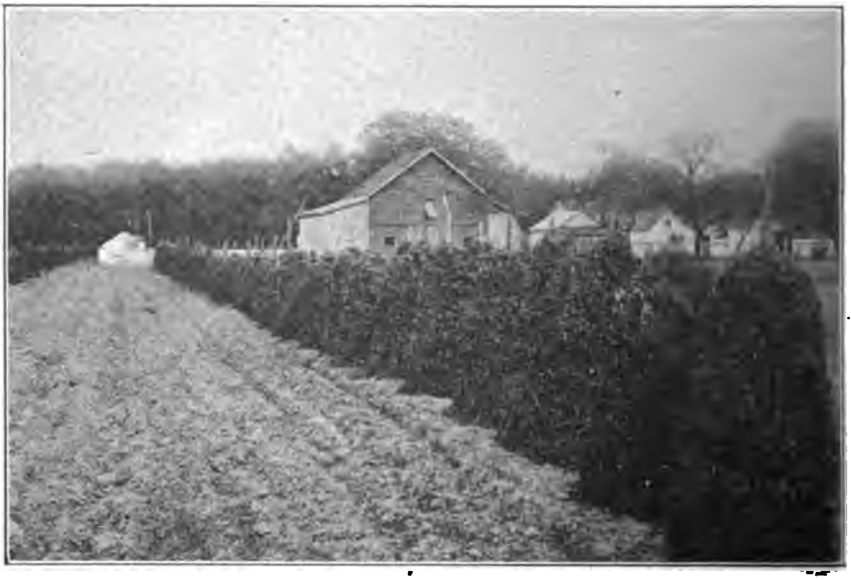

FIG. 13.—Peanut shocks placed close together near farmyard.

In some localities the pickers are paid by the hundred pounds, 40 cents a hundred being the average price paid. At this rate the cost of picking the peanuts grown on one acre will vary from $4 to $8.

Use of machines for picking.—Two types of machines have been employed for picking peanuts from the vines, and most of the work done by them has been quite satisfactory. A cylinder machine similar to a regular grain separator except as to size has been used for several years, especially in the districts where the Spanish variety is extensively grown. The principal objection to all the cylinder machines is the tendency to break the pods and both shell and injure the peas. By running the cylinder quite slowly, say at 400 revolutions a minute, and feeding properly it is possible to thrash peanuts by using a cylinder machine with a very small percentage of loss from breakage. Pods that are merely cracked or that have what the growers term "oyster mouths" will not keep for a long period but become rancid or are injured by small insects while in storage.

There is a machine in use which works upon an entirely different principle from the cylinder machines and which does not break or injure the pods. In this machine the picking is done by dragging the vines over a horizontal wire mesh, and at the same time brushes act on the lower side of the wire screen to remove the nuts. Very little power is required to operate this machine, two complete outfits being run at once by a 5-horsepower gasoline engine. The capacity of this machine is from 300 to 500 bushels a day. In addition to removing the pods from the vines the machine has the usual cleaning arrangements and a device for removing the small stems from the pods, delivering them in a condition suitable for the cleaning factory. Figure 15 shows one of these machines in operation.

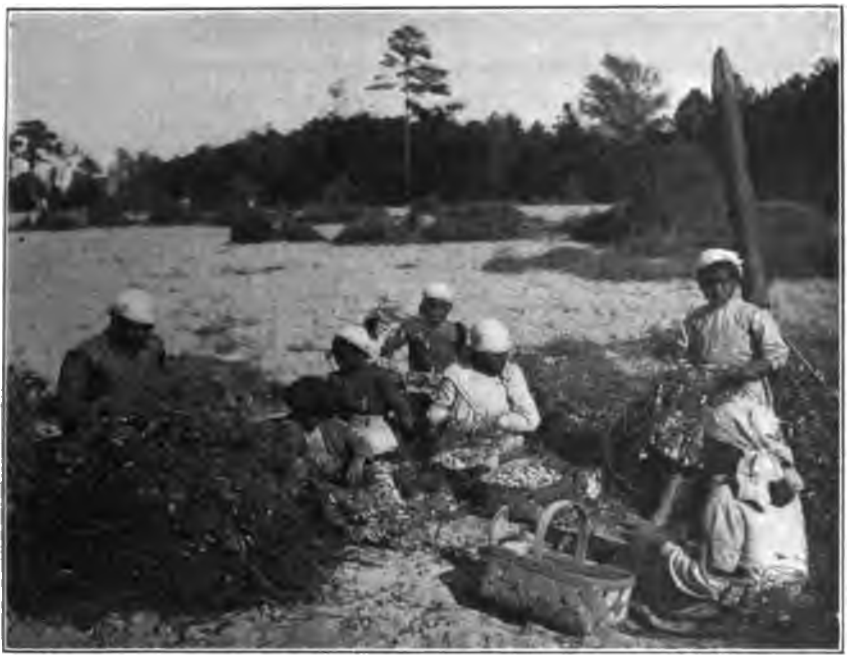

FIG. 14.—Picking peanuts from the vines by hand.

Care of peanuts after picking.—At no time after the curing process should the peanut pods be exposed to water, or even dampness, as the shells invariably become darkened and discolored by the addition of moisture. When properly cured the shells will be covered with a fine, dry dust, and where this dust becomes moistened it adheres and forms a brownish spot. If the peanuts show the least trace of dampness after their removal from the vines, they should be spread on a floor or stored in a well-ventilated building until thoroughly dry. Many of the larger growers have provided narrow cribs similar to those employed for the storage of corn, and the peanuts are kept in bulk until sold. When the pods are thoroughly dry they may be put into bags as they come from the machine, and either hauled direct to the cleaning factory or stored in small lots.

Preparation of peanuts for market.—As the peanuts come from the hands of the pickers or the thrasher they contain considerable rubbish and have more or less soil adhering to the pods. The extent to which the pods must be cleaned and graded will depend upon the use to which they are to be put; if for vending purposes they will require a factory process, but if for shelled nuts very little work will be necessary to prepare them for the sheller. Under the present status and extent of the peanut industry the cleaning factory has become an important factor, and the interests of the grower and cleaner are correlative and should be cooperative. Where Spanish peanuts are grown on an extensive scale it may be feasible for the farmer to own and operate a small shelling and cleaning outfit. In the case of the large-podded varieties several grades are made from one class of stock, requiring an extensive, although simple, equipment and the handling of large quantities of nuts in order to make the enterprise profitable.

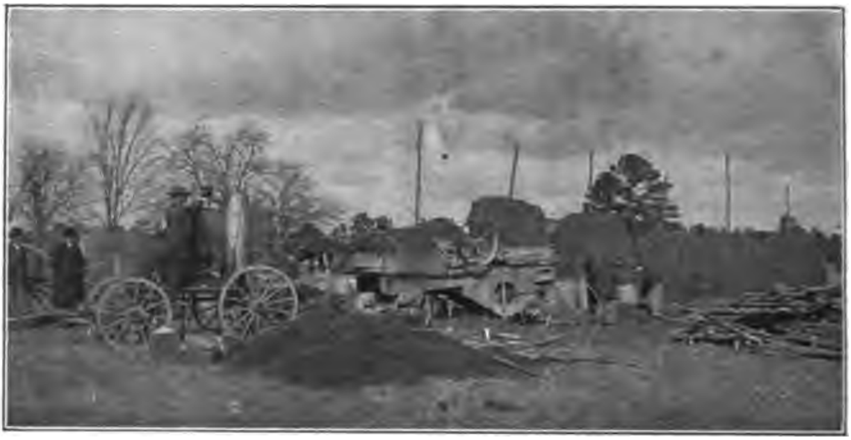

FIG. 15.—An improved type of peanut-picking machine in operation.

Methods of cleaning peanuts in the factory.—The cleaning or factory process consists chiefly in the removal of all dirt and the separating of the nuts into their respective grades. In addition to grading, the higher class product is treated to a polishing process, which gives the pods a more attractive appearance when exposed for sale. The modern peanut-cleaning factory consists of a four or five story building, which is supplied with power, lighted by electricity, and provided with elevators and bins for handling and storing the unclean nuts. It also has a full equipment of fans, grading machines, polishing drums, and shellers, and an abundance of lower-floor space for the storage of the bags of nuts that are ready for marketing.

When the peanuts are received from the farmer at the factory they are weighed and then elevated to the top floor of the factory. During the cleaning and grading process they descend by gravitation through the fans and graders, are tumbled in the polishing drums together with a small quantity of marble dust to whiten and polish the pods, are passed on slowly moving belts between lines of women who are expert in detecting foreign matter and inferior nuts, and finally drop into bags on the lower floor.

In the modern cleaning factory all dust and refuse is removed by means of fans and ventilators, the portions of sticks, stems, and broken shells being conveyed to the boiler room and fed into the furnace. One advantage of a factory process is that nothing need be wasted, as all broken or split peas can be worked into the stock used in the manufacture of peanut products.

Cleaned vines as stock feed.—The peanut vine or straw from which the nuts have been removed is of considerable value for feeding purposes. Where the peanuts are picked from the vines by hand the stems become broken and the greater portion of the leaves is lost, but where machines are used for picking it is possible to save the straw in fairly good shape. If the vines are carefully handled during the curing process and then put in barns or stacks that keep out rain, the straw when delivered from the thrasher will have a feeding value about equal to clover hay. If the vines are bright and clean after the pods have been removed they can either be sold or fed to farm animals, and they will in this way partially pay for the cost of planting and cultivating the crop. Some growers employ a baling press and bale the straw as it comes from the thrasher in order that it may be more easily stored and also be available for marketing.

VARIETIES OF PEANUTS.

There are not more than five or six distinct varieties of the peanut grown in the United States, but these few varieties represent at least three separate types. By classifying the varieties of peanuts according to types we have first the large-podded, or Jumbo, peas and the small-podded peas. These types are subdivided into bunch and running peas. Figure 16 shows pods and peas of the more important commercial varieties.

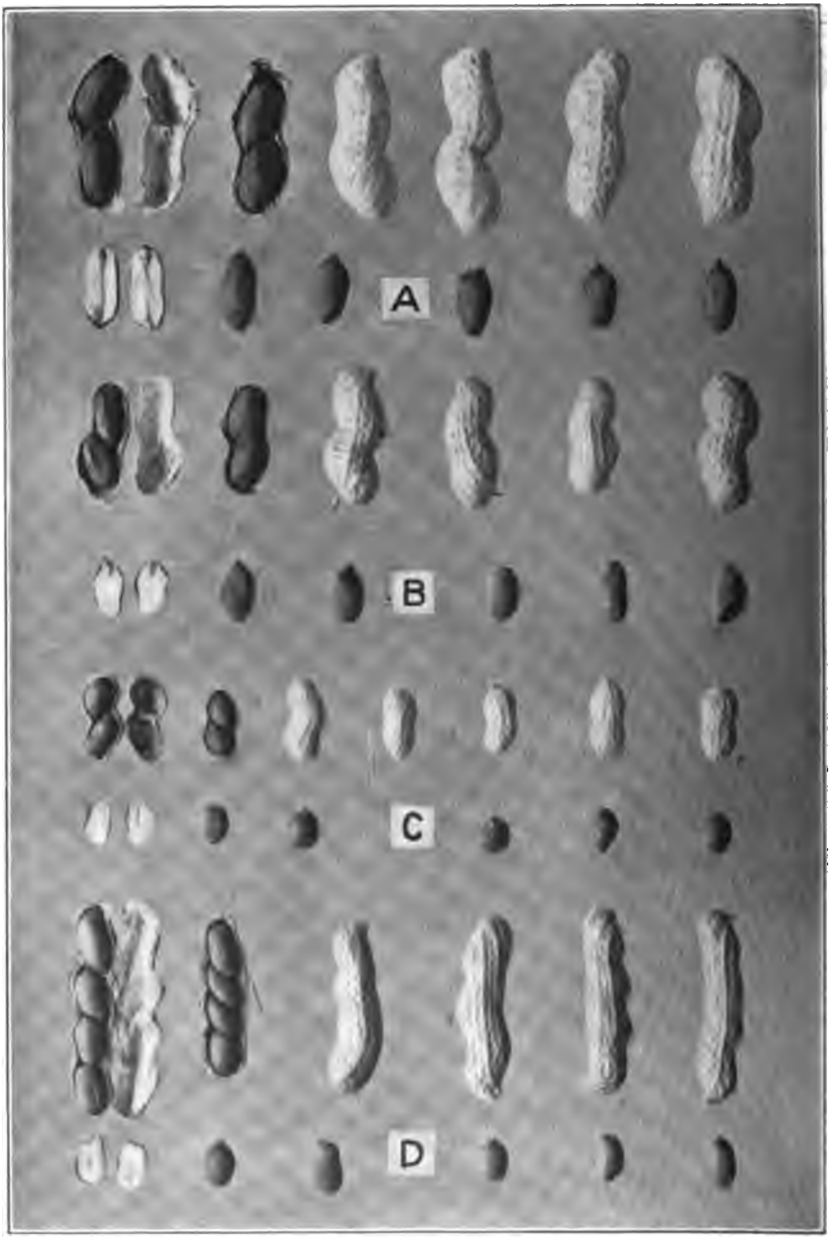

FIG. 16.—Commercial types of peanuts. (A) Virginia Bunch or Virginia Runner; (B) North Carolina; (C) Spanish; (D) Tennessee Red. (About one-half natural size.)

Those varieties having a bunch habit of growth are most generally grown, owing to the fact that they may be planted closer together than the running varieties. The bunch varieties are also more easily cultivated and harvested than are the runners.

DESCRIPTIONS OF VARIETIES.

The following descriptions of the more common varieties of the peanut may be of interest to those not already familiar with them:

Virginia Bunch.—Large-podded variety, plant rather dwarf, stems upright, foliage rather light; pods clustered about the base of plant; usually two, sometimes three, seeds in a pod, pod bright and clean, color of peas light brown; pods adhere well to plant in digging. The customary weight per bushel of this variety is 22 pounds. (Fig. 17, and fig. 16, *A*.)

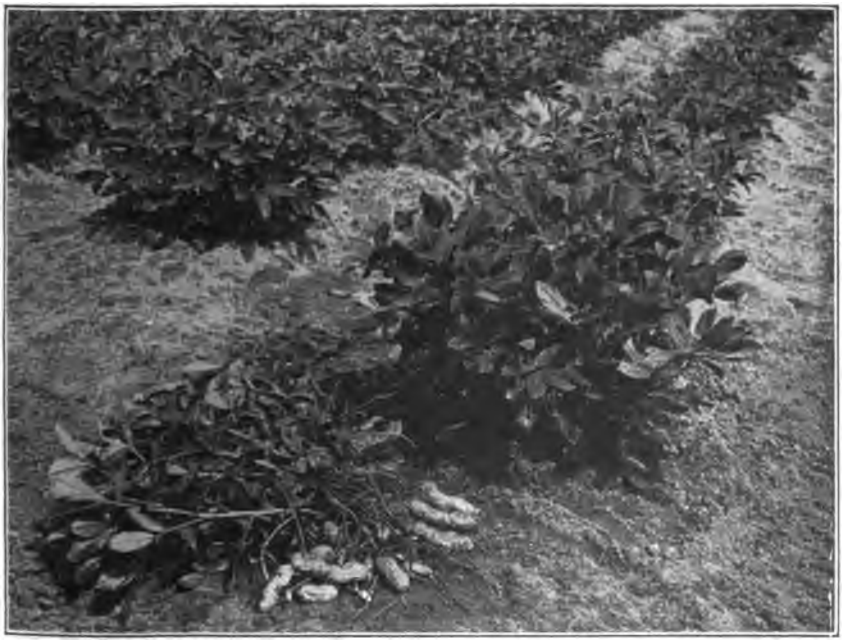

FIG. 17.—Virginia Bunch type of peanut.

Virginia Runner.—Large-podded variety, strong grower, stems creeping, foliage heavy; pods scattered along procumbent stems, pods and peas very similar to those of the Virginia Bunch; pods do not adhere well in digging. The customary weight per bushel of this variety is 22 pounds.

North Carolina.—Similar to Virginia Runner, except that plant is not so large or vigorous and pods and peas are both smaller. This variety contains a high percentage of oil. (Fig. 16, *B*.)

Spanish.—Small-podded variety, strong grower, stems upright, foliage abundant and heavy; pods clustered about base of plant;

usually two seeds in a pod, entirely filling the pod: pods rough and inclined to be darkened in color: color of peas light brown; pods adhere well to plant in digging. This variety frequently yields 60 bushels of marketable peas and 2 tons of hay to the acre. The peas of this variety are rich in oil content. The weight per bushel of Spanish peanuts is 28 pounds. (Fig. 18 and fig. 16, *C*.)

Tennessee Red.—Small-podded variety; similar to Spanish, except that the pods are longer, sometimes containing five or six peas crowded together; peas dull red in color. This variety is well adapted to stock feeding, but does not sell upon the market owing to the color and quality of the peas. (Fig. 16, *C*.)

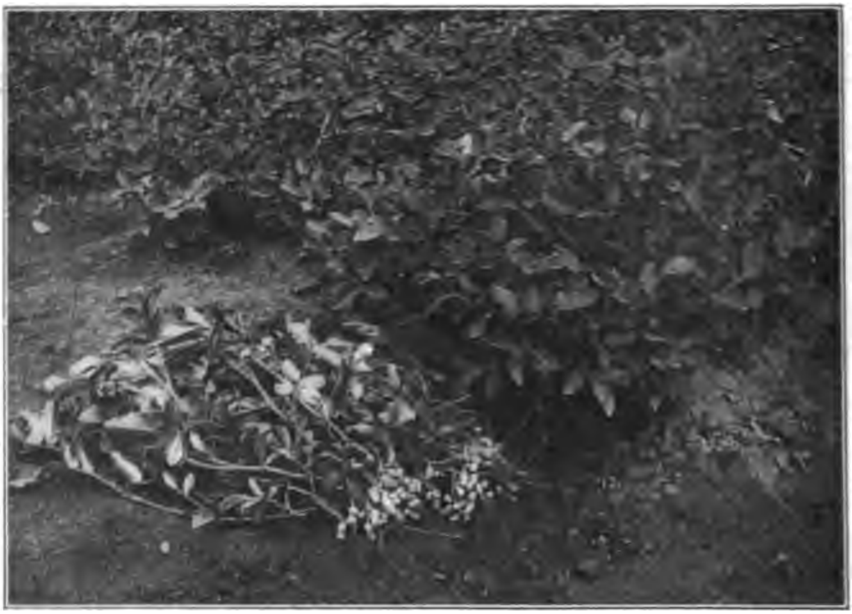

FIG. 18.—Spanish type of peanut.

Dixie Giant.—The variety known as Dixie Giant is so called owing to the great size of its pods. It is distinctly a novelty, does not yield well, and requires a long season for the pods to mature. Recommended only for southern part of Gulf Coast States. The peas of this variety are very large and are desirable for the manufacture of fancy blanched nuts.

VARIETIES FOR MARKETING.

For vending purposes, where the peas are roasted and sold from the fruit stands, the large-podded varieties, including Virginia Bunch and Virginia Runner, are in greatest demand, although considerable quantities of Spanish and North Carolina are used for this purpose. For shelled peas the smaller nuts of the large-podded stock are employed; also the greater part of the crop of Spanish, North Carolina, and Tennessee Red varieties. A large percentage of stock that is shelled is of the variety known as Spanish.

VARIETIES FOR STOCK FEEDING.

When peanuts are grown exclusively for feeding purposes the Spanish is undoubtedly to be preferred. If it is desired to market the high-grade portion of the crop and feed the remainder, the question of variety to be grown will depend largely upon locality. Many growers throughout the peanut area follow the practice of planting several acres of Spanish peanuts and disposing of all of the better-grade peas to some factory for shelling purposes, the vines and poorly filled pods being fed to the farm animals. The Spanish peanut can be grown under a much broader range of conditions than can the large-podded sorts and should be employed where the season is short.

This variety also produces a heavy yield of vine and is desirable for forage purposes. The Tennessee Red is very similar to the Spanish in habit of growth and is desirable for stock feeding, but as this variety does not sell readily upon the market it is not generally recommended.

THE USES OF THE PEANUT.

To most persons the peanut suggests only the article as it appears for sale whole or shelled and salted, but during recent years the uses of peanuts have become numerous, and include a wide range of utility. The demand for peanuts for use in the manufacture of food preparations is constantly increasing. By-products of the peanut are now being employed extensively in the manufacture of feeds for farm stock and dairy cows, and the plant is being largely utilized as forage and as a soil renovator.

Important uses for human food.—Among the more important uses of the peanut for human food are the following: It is eaten from the shell, as salted shelled peas, as blanched peas, in the so-called peanut candies and brittle, in combination with pop corn and puffed rice, in the form of peanut butter, and as an ingredient of peanut and vegetable meats, peanut meal, and salad oils.

The use of the peanut for eating from the shell when roasted is most important and popular, but the quantity of shelled peas that are first roasted and then salted and sold by the pound is constantly increasing.

A comparatively small quantity of the better grades of peanuts is first shelled and then roasted and the thin brown covering removed, after which the halves of the peas are broken apart, the small germ removed, and the meats given a blanching process which renders them very desirable for table use.

Greater quantities of shelled peas are used every year in the manufacture of peanut candies and brittle, both alone and in combination with other nuts, pop corn, or puffed rice. A very desirable kind of peanut candy can be made by simply boiling shelled peanuts with a thick sirup consisting of 2 pounds of granulated sugar and one large cupful of water, together with a teaspoonful of lemon juice. When the sirup begins to boil add 2 pounds of unroasted shelled peas and cook slowly until the peas are tender and the sirup sufficiently hard to break when quite cold. The cooking process should as a rule continue for about an hour, when the mixture should be poured on a cold buttered platter to cool. Peanut candies are as a rule not adapted to handling in warm weather and should be kept cold after making.

During recent years great quantities of shelled peanuts, especially of the Spanish variety, have been employed for the manufacture of peanut butter. This butter is prepared by the ton in factories, is put up in bottles or tins containing from one-fourth pound to 5 pounds each, and has become very popular as a part of the luncheon menu and for camping and cruising supplies. In the process of the manufacture of peanut butter the shelled peas are first given a medium roast, care being taken that the meats do not become overdone or scorched. The peas are then fanned and screened to remove the thin brown coverings and the germs, after which they are ground to a pulp by means of a special grinder similar to those used for chopping meats. As the peanut pulp comes from the grinder it is fed through a tin tube into the bottles or tins and tightly sealed. Some manufacturers follow the practice of salting the peanut butter, while others leave this part of the process for the consumer, who can easily salt to suit the taste.

By a little experience and the aid of a small meat grinder, any one can make good peanut butter for home use. The peanuts may be roasted before or after shelling, but in either case the oven should be only moderately hot and the peas should be stirred frequently. After roasting, rub off the skins and screen out the small germs, or hearts. In grinding, use the finest plate on the grinder and screw up the tension until the crank will be quite hard to turn. If the pulp is too coarse after one grinding it may be run through a second time. It will not be necessary to add anything but a little salt to the butter, but if desirable the butter may be thinned by the addition of a little olive oil.

In the preparation of vegetarian meats a portion of the oil is expressed from the ground peanuts, other ingredients, including various vegetable substances, are added, and the whole is crushed and pressed into tins ready for use. In this case the extra oil is either used for thinning peanut butter or sold as a compound for use in further cooking the vegetable meats.

Peanut meal, made from finely ground blanched peanut meats, is used to some extent in confections. This meal is especially desirable in the manufacture of almond macaroons and small cakes, to which it imparts the desired almond flavor. This meal is also used in the manufacture of candies.

Peanut oil is used in the same manner as olive oil; also for mixing with cotton-seed oil in order to improve the quality of the cotton-seed oil for salad purposes.

The uses of peanut by-products as foods for live stock.—In the factories where peanuts are cleaned, shelled, and graded ready for the market there is always a certain percentage of cleanings and inferior stock that can readily be turned into stock foods. The outside shell, or hull, of the peanut is rich in food materials but is extremely difficult to reduce to a condition in which it can be fed. In large cleaning factories the shells are generally used as fuel, and the ash resulting therefrom is valuable as a fertilizer, often containing as high as 3 per cent of phosphoric acid, 9 per cent of potash, and 6 per cent of lime.

The thin brown covering of the peas has a feeding value almost equal to that of wheat bran. These hulls are especially desirable for mixing with the smaller particles of broken peas for stock feeding. In large factories where peanuts are prepared for the manufacture of peanut butter and similar preparations the waste in the form of small particles of the meats and the germs is considerable and is sold to farmers for feeding purposes. In some cases the waste is mixed with a portion of the hulls and finely ground or chopped before leaving the factory. Peanut hulls can not readily be ground by means of a burr mill but require some form of chopping or shredding process.

Broken peas and germs are used largely as a food for hogs, and both should be fed in moderation and in combination with some grain, as the peanut feed by itself will produce a hog having soft fat and inferior meat. The famous Smithfield hams and bacon come from hogs that are partially fed on peanuts, the practice being to turn the hogs into the peanut fields after the crop has been gathered and allow them to glean the pods that were lost in harvesting. The principal objection to the use of peanut by-products as stock feeds is their tendency to become rancid very quickly. The germs, which are high in nitrogen content, become rancid and bitter in a short while and should not be kept on hand for a greater period than fifty or sixty days.

Possibilities in the manufacture of peanut oil.—The oil of the peanut belongs commercially in the same class as do cotton-seed and olive oils. Peanut oil is of a higher grade than cotton-seed oil and of somewhat lower value than first-class olive oil. Peanut oil is sometimes used for mixing with olive oil for the production of an oil that can be sold at a lower price than pure olive oil. On the other hand peanut oil is frequently mixed with cotton-seed oil in order to improve the quality of the cotton-seed oil for certain purposes.

The quantity of oil that may be obtained from the peanut will depend upon the variety, the maturity of the peas, and the apparatus with which the extraction is made. The Spanish meats when shelled and thoroughly cleaned frequently contain as high as 45 per cent of oil, as shown by chemical analysis, although not more than 34 per cent can be expressed by the best of present methods and perhaps about 28 per cent by ordinary machinery. It is generally conceded that in order to make the manufacture of oil profitable good peanuts must be obtainable at prices not exceeding 40 cents a bushel. A bushel of first-class Spanish peanuts, weighing 28 pounds, will produce about 1 gallon of oil, worth 45 cents, and 20 pounds of oil cake and hulls, which when ground and mixed together will be worth approximately 25 cents, or $25 a ton, as stock feed.

The greater portion of the peanut oil of commerce is manufactured at Marseille, France, from peanuts that are bought very cheaply along the coast regions of Africa and transported by ships as return cargo. The African-grown peanuts are very rich in oil, often containing as high as 50 per cent. With a coming shortage of cotton seed from which to manufacture oil in this country there is a great possibility of building up a peanut-oil industry throughout the cotton belt of the Southern States. As already mentioned, there are thousands of acres of land now lying idle that will produce fairly good crops of peanuts, and their growth will improve the land. By combining the use of cotton seed and peanuts for the production of oil it would be possible to keep the existing oil mills of the South running and at a profit to both the farmer and mill owners. The oil that remains in the cake will not be lost, as there is demand for the cake for the manufacture of vegetarian meats and for stock feed.

The process of expression is very similar to that for cotton-seed oil and the greater portion of the machinery of the present oil mills is adapted to the manufacture of peanut oil. It would be necessary, however, to add special appliances for shelling, cleaning, and macerating the meats of the peanut.

THE IMPORTANCE OF THE PEANUT AS A FARM CROP.

In sections where the soil and climate are suitable the peanut is rapidly becoming a crop of general farm importance. In the Southern States peanuts can be grown under a wide range of conditions, and the product can be used for several purposes. Peanuts are valuable as a substitute for cowpeas, especially on certain soils that are not adapted to the growing of the cowpea. In many sections where the clovers and other soil-renovating crops will not withstand the heat and drought of the summer months, the peanut will thrive and make an excellent growth. A crop of peanuts for forage can often be grown after the removal of oats or some other spring crop, and although they may be badly overgrown by crab-grass, the tops may be mown with the grass for hay, and the hogs turned in to root out the peas.

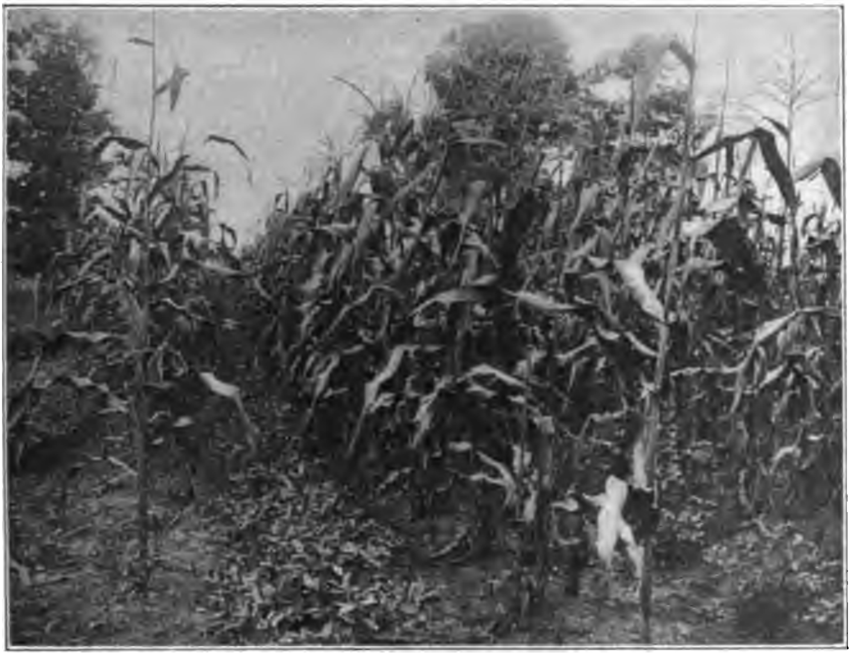

FIG. 19.—Peanuts growing in the alleys between rows of corn.

Throughout Georgia and the surrounding Gulf Coast States the peanut is extensively used for planting in the alleys between the rows of corn. The peanuts are planted at the time the corn is given the last working, and are allowed to grow as a catch crop among the corn. (Fig. 19.) After the corn is pulled, cattle are turned in to eat the fodder and the peanut tops. Following the cattle the land is pastured by hogs to clean up everything that remains. In this way most of the nitrogen stored by the peanut roots is left in the soil. Peanuts can be planted between rows of cotton in the same manner.

The value of peanut hay for feeding purposes.—The tops of the peanut plant when cut and cured in the same manner as other legumes will produce a hay that is almost equal in feeding value to the best clover hay. By planting the Spanish peanut in rows from 24 to 30 inches apart and quite closely in the row and by giving the crop about two cultivations, it is possible to produce from one to two tons of hay to the acre. After the hay is removed the pods can be turned out by means of a plow, cured, and stored for winter feeding, or hogs may be turned in to gather the crop. The following table shows the comparative value of peanut hay.

TABLE I.—*Comparative analysis of peanut hay and other hays.*

Dry matter.	Protein.	Carbohydrates.	Fats.
	Per cent.	*Per cent.*	*Per cent.*
Peanut hay	11.75	46.95	1.84
Peanut, entire plant	13.48	36.28	15.06
Clover hay	12.84	48.31	2.11
Timothy hay	7.17	52.94	1.97
Cowpea hay	19.72	45.15	4.04
Alfalfa hay	16.48	42.62	2.08

Peanut straw, consisting of the entire vine after the salable nuts have been removed, has a somewhat higher feeding value than the tops alone, due to the fact that many of the inferior pods are left in the straw. Peanut straw is, however, not so bright or palatable for feeding as are the peanut tops when cut and cured especially for hay.

The value of the entire peanut plant as forage.—Throughout that portion of the Southern States where field corn does not yield a satisfactory crop, the place of corn for feeding to animals may be largely taken by the peanut. On some ranches where a large number of work animals are maintained the Spanish peanut, including the entire plant, is practically the only feed used.

The peanut vines and peas when chopped or ground together form almost a balanced ration for a dairy cow. The following table will give some idea of the comparative value of peanut products and other feeding stuffs.

Table II.—*Comparative analysis of peanuts and other feeding materials.*

Dry matter.	Protein.	Carbohydrates.	Fats.
	Per cent.	*Per cent.*	*Per cent.*
Ground corn and oats	9.6	71.9	4.4
Corn meal	9.2	68.7	3.8
Wheat bran	15.4	60.4	4.0
Cotton-seed meal	42.8	23.6	13.1
Peanut kernels	26.6	16.7	42.0
Peanut vines	10.0	42.0	8.6
Clover hay	12.4	38.8	4.5
Alfalfa	14.3	42.7	2.2
Peanut, whole plant	18.4	40.1	21.5

The use of peanuts for fattening hogs.—As already suggested, the peanut is a valuable feed for use in preparing hogs for market, the usual custom being to turn the hogs into the peanut fields and allow them to glean whatever is left after harvesting. In some sections peanuts are being grown primarily for feeding to hogs. Poorly filled nuts, broken peas, the germs, and waste products generally are fed to hogs during the earlier part of the fattening period. A hog that is fattened exclusively on peanuts will not yield a desirable class of meat or lard, as the meat will lack firmness and the lard be soft and oily. Toward the end of the fattening period the hog should be fed almost exclusively on corn. Hogs will eat considerable of the peanut tops when pastured on them, and the plan of dividing the field into small areas by portable fences and allowing the hogs to gather the peas is perhaps the most economical.

Methods of handling and curing peanuts for forage.—Where the entire peanut plant is to be stored and used for feeding to stock the work of curing and caring for the vines should be very much the same as in curing cowpea hay, although the peanut vines will cure more rapidly than those of the cowpea. The vines are plowed from the soil or lifted by means of a potato digger, and after being allowed to lie exposed for a few hours are raked into very small windrows by means of an ordinary hay rake. After partially drying in the windrows the vines are put up in small shocks, preferably around poles. The main object in the handling of peanut vines for forage will be to get the stems and peas properly cured without losing the leaves, and in order to do this it is necessary to keep them in bunches and to dry them gradually. After the vines are sufficiently dry they may be stacked around a pole or hauled to the barn and stored in the hay mow. Where the stacking method is employed the stacks should be rather small, say not over a ton each.

Peanut vines for forage purposes can be handled in the same way as those of the cowpea and yield a very desirable class of forage. Persons who have used the peanut exclusively for feeding purposes claim that they have had no difficulty in feeding it to all kinds of work animals, even driving horses. It is well, however, to feed only a part ration of peanut vines at first and observe the animals until they become accustomed to this form of diet. Under ordinary circumstances the plant is fed without removing the nuts, but it may be well in some cases to pick the peanuts from the vines and grind them, shell and all, and then feed as a meal with the vines.

INSECTS INJURIOUS TO THE PEANUT.

The insect enemies of the growing peanut crop have been so few that very little attention has been given them by the entomologists. Recently there has been reported a species of aphis working upon the roots of the peanut plants. This insect belongs to a class that obtains its food by sucking the juices of the plant from beneath the surface of the leaves, stems, or roots. The presence of this root aphis is indicated by patches of what appears to be a white mold upon the roots and pods of the peanut and is generally not observed until digging time. Thus far no great injury from these insects is apparent, but should they become very numerous great damage will ensue, and about the only satisfactory remedy which the writer can suggest is crop rotation, planting peanuts on clean land each year, and only returning to the original piece after a period of four or five years.

While in storage peanuts are attacked by various insects. So long as the shells remain unbroken these insects can not gain access to the meats, but where the shells have been injured or broken in thrashing or in subsequent handling the peas can not be kept during the summer months. These insects are especially destructive in storage houses and cleaning factories where peanuts are held for summer trade. They may be destroyed by fumigation with carbon bisulphid in the factory or warehouse. Carbon bisulphid forms an inflammable gas, and its use is attended with some danger and should be applied by an experienced person.[a]

DISEASES OF THE PEANUT.

The peanut crop has thus far been remarkably free from disease. About the only disease that has been at all prominent is a form of leaf-spot (*Cercospora personata* (B. & C.) E. & E.) which appears in the form of small brown spots on the leaves. (Fig. 20.)

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[a] For information regarding the use of this insecticide the reader is referred to Farmers' Bulletin 145, which may be obtained upon application to the Secretary of Agriculture. No general work has been published by this Department on the insect enemies of peanuts, but information in regard to any of them may be obtained by application to the Bureau of Entomology. Correspondence will be facilitated if specimens of the insects concerned in the damage accompany letters of inquiry.

This disease is especially noticeable on the young plants during a wet spring, giving the leaves the appearance of having been scalded by the sun. Later in the season the plants will as a rule outgrow the disease, except in low or poorly drained portions of the fields. Where the disease is abundant upon the foliage the pods are frequently discolored and rusty. There can be no doubt that this disease causes considerable reduction in yield on land that is sour or poorly drained. It is often observed that the disease will be abundant in low spots without spreading to other parts of the field. The presence of the disease upon the foliage of the peanut greatly decreases the value of the vines for hay. Should this trouble become prevalent it may be controlled by spraying with Bordeaux mixture. Its development may be prevented by proper drainage.

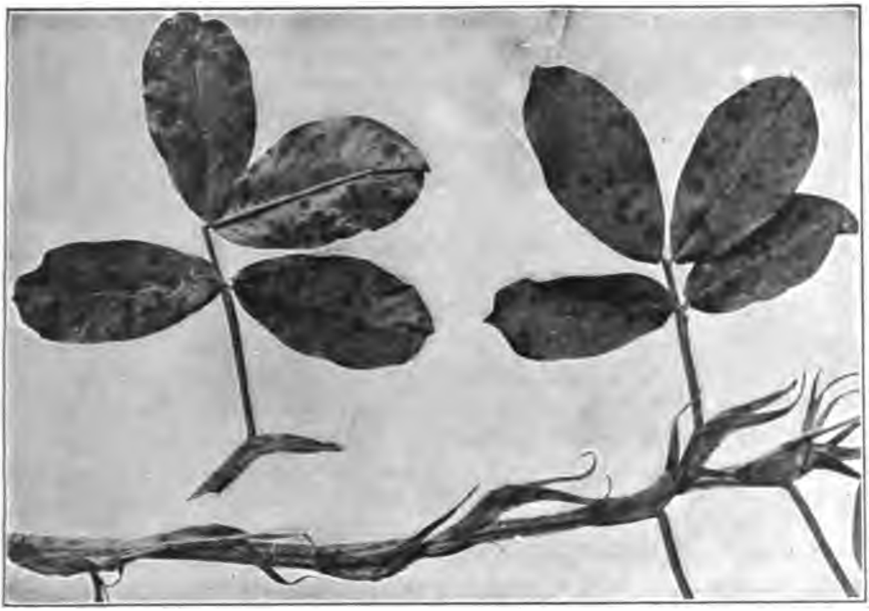

FIG. 20.—Disease appearing upon the leaves of the peanut.

CONCLUSIONS.

The peanut is worthy of more general cultivation throughout the Southern States, especially in the boll-weevil district, where it will in many cases be found more profitable than cotton.

The uses of peanuts as a general farm crop throughout the Southern States are becoming more numerous, especially as a means of

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., January 20, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Methods of Poultry Management at the Maine Agricultural Experiment Station," which is mainly a compilation and revision of material contained in Bulletin 90 of this Bureau and in various bulletins of the Maine station, the authors of which were Dr. Charles D. Woods and the late Prof. Gilbert M. Gowell. In addition there are included descriptions of such new and improved methods and appliances as have been put into practice since those bulletins were issued. The work of compilation and revision has been done by Dr. Raymond Pearl, Expert in Poultry Breeding of this Bureau and Biologist of the Maine Station. Credit for originating the methods and practices described, with a few exceptions, belongs to Professor Gowell.

Poultry investigations have been a special feature at the Maine station for many years, and the results of the experimental and practical work have been of much value to poultrymen throughout the country. Since 1904 the work has been carried on by cooperation between the station and this Bureau. As there has been a very large demand for information as to the methods of poultry management employed at the Maine station, and as the publications mentioned are no longer available, the present paper has been prepared and is respectfully recommended for publication as a Farmers' Bulletin.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction.......... 5

The selection of breeding stock.......... 5

  Early laying a valuable indication.......... 5

Raising chickens by natural processes.......... 6

Raising chickens by artificial processes.......... 8

  The incubator.......... 8

  The incubator room.......... 9

  Brooder houses.......... 10

  Treatment of young chicks.......... 13

  Feeding young chickens.......... 13

Feeding chickens on the range.......... 17

  The feeding trough.......... 18

Feeding the cockerels for market.......... 19

Housing the hens.......... 20

  The roosting-closet house.......... 21

  Curtain-front houses.......... 22

    The latest form of curtain-front house.......... 25

    Advantages of curtain-front houses.......... 30

The yards.......... 31

Feeding the hens.......... 31

A poultry-house disinfectant.......... 34

Trap nests.......... 36

ILLUSTRATIONS.

Page.
FIG. 1. Portable brooder house.. 11
2. Chicken-feeding trough.. 18
3. Chicken-feeding trough with cover removed........................ 19
4. Interior of curtain-front poultry house No. 2........................ 24
5. The latest curtain-front poultry house........................ 25
6. Floor plan and front elevation of section of latest curtain-front poultry house........................ 28
7. End elevation of latest curtain-front poultry house........................ 29
8. Trap nest closed. View from above........................ 37
9. Trap nest open. One side removed to show method of operation 38
10. Trap nest closed. One side removed to show method of operation..... 39

METHODS OF POULTRY MANAGEMENT AT THE MAINE AGRICULTURAL EXPERIMENT STATION.

INTRODUCTION.

Many years' practical experience in raising and keeping poultry and investigations in poultry breeding at the Maine Experiment Station have resulted in the accumulation of a considerable fund of information on poultry management. It is the purpose of the following pages to outline this experience for the benefit of poultry keepers and thereby to help them to discriminate between some of the wrong theories which have underlain much of the common practice of the past and the better theories which underlie other and newer methods that are now yielding more satisfactory results. It may be that these methods are no better than those practiced by others, but the attempt is made to state concisely the methods which have been or are now being successfully employed at the station.

THE SELECTION OF BREEDING STOCK.

There are two or three much-advertised methods of judging a hen's productiveness from certain signs and marks, the secret of which will be disclosed by the inventor for a monetary consideration. The Maine station has not invested in nor investigated any of these methods. There may be ways to prophesy accurately what a hen will do in the way of egg production, but they have not come to the writer's attention.

EARLY LAYING A VALUABLE INDICATION.

The only absolutely sure way of making selection for breeding stock is by means of the data obtained from the use of trap nests. Only investigators and an occasional poultryman, however, can afford the equipment and the expense involved in operating trap nests, but every poultryman can, by closely observing his young stock during the autumn, select the pullets that are commencing or preparing to lay, and secure for the next season's breeding a pen of birds that have the function of egg production so strongly developed that they give evidence of it by its early exercise.

As evidence of the value of early-laying pullets, attention is called to the work performed by 29 April-hatched pullets that were selected from among their sisters out on the range in August and September, when they showed that they were laying or about to begin laying. They were not selected because of form or type as indicating egg production, but they were either just picked up as they were found on the nests or taken because their combs were red or because they tagged the attendant around and prated in the everyday hen language about the work they were soon going to do. They were carried to the laying house, marked with bands, and given access to trap nests.

Four of the 29 died within the year. The smallest layer of the remaining 25 laid 137 eggs the first laying year; 18 laid more than 160 eggs; and 8 laid over 200 eggs, and the average of the flock for the twelve months ending August 30, 1905, was 180 eggs. This average was much higher than that of all the pullets carried that year, and the flock contained no poor layers, but a phenomenal number of high layers. The high average of the flock and the large proportion of good layers point out the advantages of this method of selection when the use of trap nests, or other equally reliable methods of selection, is not practicable.

Poultrymen are generally desirous of securing as many well-bred pullets as possible, and so use 1-year-old hens as breeders in addition to their 2-year-olds. The work done by pullets from September to February or March is a pretty good indication of their usefulness, and their eggs are available for breeding during the pullet year. While the chickens from such eggs are not generally so large at maturity as those from older hens, they do not appear to lack constitution or vigor, and there is no apparent reason why they are not desirable for breeding purposes.

RAISING CHICKENS BY NATURAL PROCESSES.

While even the small grower of chickens in many cases uses an incubator for hatching, circumstances sometimes make it necessary to hatch and raise chickens by aid of the mother hen. To persons so situated an outline of the method practiced at the station before incubators had reached their present development may be helpful. An unused tie-up in a barn was taken for the incubating room and a platform was made along the inner side. The platform was 3 feet above the floor and was 2½ feet wide and 50 feet long. It was divided into fifty little stalls or nests, each 1 foot wide, 2 feet long, and 1 foot high. This left a 6-inch walk along the front of the nests for the hens to light on when flying up from the floor. Each nest had a door made of laths at the front, so as to give ventilation. The door was hinged at the bottom and turned outward. Across the center of each nest a low partition was placed, so that the nesting material would be kept in the back end—the nest proper. For early spring work paper was put in the bottom of the nest, then an inch or two of dry earth, and on that the nest, made of soft hay.

Whenever half a dozen hens became broody they were taken in from the henhouse and put on the nests, each nest having a dummy egg in it; the covers were then shut up, and nearly every hen seemed contented. In a day or two 13 eggs were placed under each hen. Every morning the hens were liberated as soon as it was light, when they would come down of their own accord and burrow in the dry dust on the floor, eat, drink, and exercise, and in twelve or fifteen minutes they would nearly all go onto the nests voluntarily. In the afternoons one would occasionally be found off the eggs looking out through the slatted door. If she persisted in coming off she was exchanged for a better sitter. The double nest is necessary, otherwise the discontented hen would have no room to stand up, except on her nest full of eggs, and she would very likely ruin them. There was no danger of this with the double nest, as she would step off the nest, go to the door and try to get out.

The advantages of a closed room in which to confine the sitters are many, as the hens are easily controlled and do not need watching as they do when selecting nests for themselves, or when sitting in the same room with laying hens. A room 12 feet square could be arranged so as easily to accommodate 50 sitters.

The most satisfactory arrangement used at the Maine station for the accommodation of the hen with her brood of young chicks consisted of a closed coop about 30 inches square, with a hinged roof and a movable floor in two parts, which would be lifted out each day for cleaning. This little coop had a wire-covered yard attached to it on the south side. The yard was 4 by 5 feet in size and 1½ feet high. Its frame was of 1-inch by 3-inch strips and was fastened securely to the coop.

The wire on the sides was of 1-inch mesh, but on top 2-inch mesh was sufficient. Such a coop is easily kept clean, and the coop and yard can be set over onto clean grass by one person.

The small run will be sufficient for the first few weeks, but soon the chicks need greater range, and then the fence at the farther end of the run can be lifted up 3 or 4 inches and they can pass in and out at will, while the mother will be secure at home and they will know where to find her when they get cold or damp or need brooding. Such a coop accommodates 15 to 20 chicks until they no longer require brooding, after which several flocks should be combined in one and put in a portable house on a grassy range.

Whenever the hen is allowed to hatch or to mother chicks, much care must be exercised to prevent lice from getting a foothold and ruining the birds. The free and frequent use of fresh insect powder upon the hen, working it through the feathers to the skin, is one of the best methods for destroying the pests. Grease or oil is effective when applied to the heads and under the wings of young chicks, but care must be taken not to get too much on them, especially during damp weather. The feeding of chicks raised in coops with their mothers does not vary much from the feeding of those raised in brooders as described on page 11.

RAISING CHICKENS BY ARTIFICIAL PROCESSES.

Incubators have been so much improved that there are several kinds on the market that will hatch as many chicks from a given lot of eggs as can be done by selected broody hens. They require little care, maintain an even temperature, and are easily adjusted to meet the increase in temperature arising from the developments going on in the eggs. In some machines the moisture supply is automatic and adapted to the requirements; in others it has to be supplied, and skill is necessary in determining the quantity needed. The economy of the incubator is very great. A 360-egg machine will do the work of nearly 30 broody hens, and can be kept at work continually if desired.

THE INCUBATOR.

There are many makes of incubators on the market, most of which will give fairly satisfactory results. The Maine station has not tested many makes of incubators, and very likely some of the makes not tested would prove as satisfactory as the make used. Where many machines are used the hand turning of the eggs absorbs considerable time. Several turning devices are in vogue and equally good hatches have been obtained with them as when the eggs have been turned by hand. Machines that have artificial turning shelves will not hold quite as many eggs as when flat shelves are used, but the saving of time compensates for this.[a]

Whatever make of incubator is used, pains should be taken to become thoroughly acquainted with the machine before the eggs are put into it. It is advisable for a person not familiar with the use of an incubator to run the machine empty for several days before filling it. After the eggs are put in, changes and adjustments should be made with the greatest care for fear of extreme results. By the use of an incubator it is possible to determine exactly the time when the chickens shall be hatched. With the strain of Barred Plymouth Rocks bred by the Maine station it was formerly necessary to hatch the chickens in March in order to have them ready for November laying. By better methods of feeding, breeding, and treatment, it is now possible to delay the hatching until April and the first of May and have the pullets in good laying condition the last of October and early in November. Chickens hatched in March under the present method of breeding and feeding would in some cases begin laying in August.

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[a] A complete and useful discussion of the different types of incubators and the methods of managing them to get the best results is given in Farmers' Bulletin 236, "Incubation and Incubators," which may be obtained free on application to the Secretary of Agriculture, Washington, D. C.

THE INCUBATOR ROOM.

It is important that the incubator room be so situated that it can be kept at a fairly constant temperature. On this account an underground room is usually selected. For many years the well-lighted cellar under the wing of the farmhouse was used by the Maine station. A cold or badly ventilated cellar would, however, be poorly adapted for incubators. Ventilation is very important, and where several incubators are in use artificial ventilation must be provided, in order that the machines may be furnished with clean, fresh air at all times.

In 1905 the Maine station erected an incubator house which practically consists of a well-made, light, airy cellar with a house for the poultry man above it. The incubator room, which occupies the entire cellar, is 30 feet square. The room is 7 feet high in the clear, 5 feet of which is below the level of the outside ground. It is lighted by six 3-light windows, carrying glass 10 inches by 16 inches. The cement walls are finished smooth and the cement floor is slightly inclined toward the southeast corner where the intake of the drain is located. This enables the free use of water from hose in cleaning the room preparatory to starting the incubators. Two chimneys extend to the basement floor and contain ventilating flues that have no opening into the rooms above. Entrance to the room is through a covered outside cellar stairway leading into a shed at the rear of the building. The room now contains twelve 360-egg machines in addition to several of smaller capacity.

In the directions which accompany the hot-air incubators of the type used at the station it is stated that an artificial source of moisture is not needed in operating these incubators except in very arid parts of the country. It is said that in other places the normal moisture of the atmosphere is sufficient to insure the necessary moisture in the incubator. The experience of the station indicates that except in a rather wet season this is not the case. It has been found here that in an ordinary season if no artificial moisture is supplied to the incubators there is too great an evaporation from the eggs. It is demonstrable that many eggs fail to hatch because of this dryness of the air in the incubator. It is not desirable here to enter into a detailed discussion regarding experiments on this point. It suffices to state the fact that in the station's experience better hatches have been obtained when moisture beyond that normal in the atmosphere is supplied during incubation. The most satisfactory way to supply this extra moisture has been found to be by wetting the cement floor of the incubator cellar thoroughly two or three times a day, depending on the degree to which evaporation is taking place. During the hatching season the aim is to keep the floor of the incubator cellar moist at all times.

BROODER HOUSES.

The poultry plant erected by the Maine station in 1897 included a permanent brooder house. The house was 14 feet wide by 60 feet long. Its front wall was 4 feet 10 inches high from the bottom of the sill to the top of the plate, and the back was 7 feet high. The ridge was 4 feet from the back side and 1 foot 6 inches higher than the back plate. This gave the short part of the roof back of the ridge and the long part to the front of it. The frame of the building was of 2 by 4's; it was boarded on the outside with hemlock boards, covered with paper, and shingled all over, and the building was ceiled on the inside with matched pine. This gave a 4-inch dead-air space in the walls and roof. The house also had a tight double floor with paper between. The front wall was 3 feet 8 inches high inside and the back wall 5 feet 9 inches from floor to ceiling. There was a 3½-foot door in each end; there were ten windows in the front wall, equal distances apart and 8 inches from the floor, and five windows in the back wall close up to the plate. The windows had 6 panes each of 10 by 12 inch glass and were in two parts, so as to slide up and down and admit fresh air and to keep the house cool in warm weather. The windows were all double. There were ten small doors, each 10 by 12 inches, placed close to the floor along the front wall, through which chickens could pass in and out; these doors were also double. Two galvanized iron ventilators at the top extended from the inside of the room up through the ridge and furnished sufficient ventilation during cold weather. The ventilators were regulated by means of a shut off at the ceiling.

The house was divided into ten breeding pens, each 6 feet by 10 feet 8 inches. The partitions between the pens consisted of an 8-inch board at the bottom with 3 feet of 1-inch-mesh wire above. A walk 2½ feet wide extended along the back of the building. The doors which led from the walk to the pens were made to swing both ways and were covered with wire. A brooder was placed in each pen with a lamp door opening into the walk. Each of these pens accommodated about 60 chicks in winter, or 75 in spring when they could get out into the yards. The building, being low posted, was kept warm enough in winter by the ten brooder stoves, and the temperature under the hovers was usually found in the morning about the same as it was left the night before.

This house proved to be thoroughly satisfactory, but was burned in the spring of 1897 and has not been replaced. A permanent brooder house would be indispensable for the raising of winter chickens, and a house piped for hot water would have some advantages over the one here described. The advantages are especially great when raising chickens if April or May prove to be cold or wet, for then the small houses are apt to be cold outside of the brooders. In ordinary seasons, even in Maine, little or no difficulty is experienced in raising chicks hatched in April and May in the small houses. The expenditure would be greater for the piped house, for the reason that colony houses should be provided in which the chickens may be sheltered after they leave the brooder house.

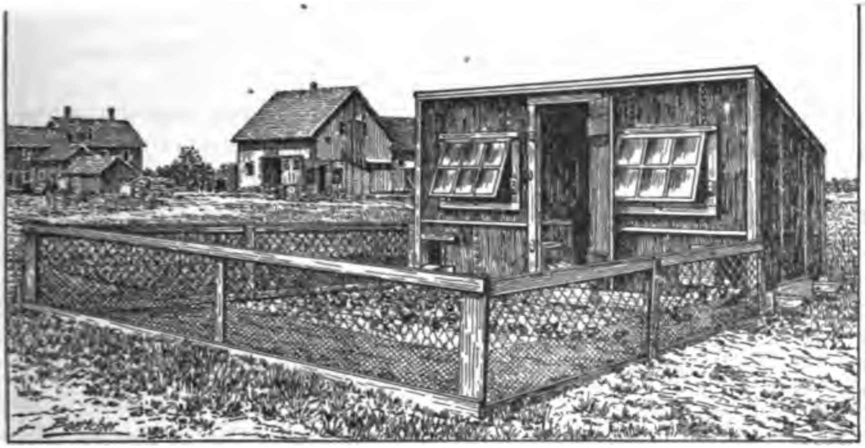

FIG. 1.—Portable brooder house.

Since the burning of the house just described, the Maine station has used small portable brooder houses (see fig. 1). The small brooder houses built on runners are readily moved about, and for the work with spring-hatched chickens are preferred to the large permanent brooder house. Several styles and sizes have been used, but the following meets the needs of the station better than any other that has been tried. The houses are built on two 16-foot pieces of 4 by 6 inch timber, which serve as runners. The ends of the timbers, which project beyond the house, are chamfered on the underside to facilitate moving. The houses are 12 feet long; some of them are 6 feet and others 7 feet wide; 7 feet is the better width. They are 6 feet high in front and 4 feet high at the back. The frame is of 2 by 3 inch lumber; the floor is double boarded, and the building is boarded and covered with a good quality of heavy roofing paper. Formerly shingles were used for the outside covering, but paper is preferred and is now used exclusively. This kind of covering for the wall is not so likely to be injured in moving as shingles. A door 2 feet wide is in the center of the front and a 6-light window, hinged at the top, is on each side of it. Two brooders are placed in each of these houses and 50 to 60 chicks are put with each brooder. A low partition separates the flocks while they are young, but later it has to be made higher. The houses are large enough so that a person can go in and do the work comfortably, and each one accommodates 100 chicks until the cockerels are large enough to be removed. One of these houses is shown in figure 1.

An improvement has recently been made in these brooder houses by providing for better ventilation. When the weather is very hot there is no movement of air within one of these houses, even though the door and windows are open. The air within the house is practically stagnant and, on account of its relatively small volume, becomes intensely hot and stifling when the temperature outside gets high. The effect on the chicks under such circumstances is bad. They retreat to the houses to get shade, but only to be injured if not killed by the hot, stifling air of the house. To remedy this difficulty a slot 2 feet long and 1 foot wide has been cut in the back of each house high up under the eaves. This slot is closed with a wooden slide running in grooves which are put on the outside of the house. The opening is covered on the inside with 2-inch mesh chicken wire. On very hot days the slide is pulled out completely so as to expose the whole opening of the slot. At night or during a period of wet, cold weather the size of the opening is regulated to suit the conditions. It enables one to keep a current of fresh air through the house in the warmest weather. The effect on the well-being of the chicks during a period of hot weather is most marked and satisfactory.

Indoor brooders are used at the Maine station and are much preferred to any outside brooders the station has tried. The style used has the cover and part of one side arranged to turn down, making an inclining run the whole width of the brooder, up and down which the little chicks can go without crowding.

Most kinds of brooders as now made keep the chicks comfortable at desired temperatures and have good means of ventilation. The great difficulty lies in the lamps used. The lamp apartments are small and the tendency is for the oil to become warm and form gases which cause the flame to stream up and make trouble. Most brooder lamps have water pans between the oil tank and the burner which tend to keep the oil cool, but even with this precaution the Maine station has had two fires, one of which was very serious. The brooders now in use have no water pans, but are so arranged that currents of cool air pass constantly over the oil tank and keep its contents cool. These lamps, or stoves, have been used for four years—last year more than 20 of them—and they are apparently safe.

TREATMENT OF YOUNG CHICKS.

When the chicks are 30 to 40 hours old they are carried in warm covered baskets to the brooders, and 50 or 60 are put under each hover, where the temperature is between 95° and 100° F. The temperature is not allowed to fall below 95° F. during the first week, or 90° F. during the second week; then it is gradually reduced according to the temperature outside, care being taken not to drive the chicks out by too much heat, or cause them to crowd together under the hover because they are cold. They should flatten out separately when young, and a little later lie with their heads just at the edge of the fringe of the hover. They should never be allowed to huddle outside of the brooder. They huddle because they are cold, and they should be put under the hover to get warm, until they learn to go there of their own accord. Neither should they be allowed to stay under the hover too much, but in the daytime should be forced out into the cooler air where they gain strength. They ought not to be allowed to get more than a foot from the hover during the first two days; then a little farther away each day, and down onto the house floor about the fourth or fifth day, if the weather is not too cold. They must not get cold enough to huddle or cry, but must come out from under the hover frequently.

The floor of the brooder is cleaned every day and kept will sprinkled with sharp, fine crushed rock, known in the market as "chicken grit." The floor of the house is covered with clover leaves or with hay chaff from the feeding floor in the cattle barns.

FEEDING YOUNG CHICKENS.

The best method of feeding young chicks is at present a matter of some uncertainty, and it is doubtful if there ever will be general agreement as to the one best method. One condition, however, appears to be imperative, and that is that the young things be not allowed to overeat. A number of different methods of feeding young chickens have been used at the station in the past. The most useful of these methods follow.

Method 1.—Infertile eggs are boiled for half an hour and then ground in an ordinary meat chopper, shells included, and mixed with about six times their bulk of rolled oats, by rubbing both together. This mixture is the feed for two or three days, until the chicks have learned how to eat. It is fed with chick grit, on the brooder floor, on the short cut clover or chaff.

About the third day the chicks are fed a mixture of hard, fine-broken grains, as soon as they can see to eat in the morning. The mixture now used has the following composition:

	Parts by weight.
Cracked wheat	15
Pinhead oats (granulated oat meal)	10
Fine screened cracked corn	15
Fine cracked peas	3
Broken rice	2
Chick grit	5
Fine charcoal (chick size)	2

It is fed on the litter, care being taken to limit the quantity, so they shall be hungry at 9 o'clock a. m.

Several of the prepared, dry, commercial chick feeds may be substituted for the broken grains. They are satisfactory when made of good, clean, broken grains and seeds, but they contain no secret properties that make them more desirable than the home-mixed broken grains mentioned above. Their use is simply a matter of convenience. When only a few chicks are raised, it is generally more convenient, and probably not more expensive, to buy the prepared feed, but when many are raised it is less expensive to use the home-mixed feeds.

Sharp grit, fine charcoal, and clean water are always before the chicks. At 9 o'clock the rolled oats and egg mixture is fed in tin plates with low rims. After they have had the feed before them five minutes the dishes are removed and they have nothing to lunch on. At 12.30 o'clock the hard-grain mixture is fed again, as in the morning, and at 4.30 or 5 o'clock they are fed all they will eat in half an hour of the rolled oats and egg mixture.

When they are about 3 weeks old the rolled oats and egg mixture is gradually displaced by a mixture having the following composition:

	Parts by weight.
Wheat bran (clean)	2
Corn meal	4
Middlings, or "red dog" flour	2
Linseed meal	1
Screened beef scrap	2

This mixture is moistened with water just enough so that it is not sticky, but will crumble when a handful is squeezed and then released. The birds are developed far enough by this time so that the tin plates are discarded for light troughs with low sides. Young chicks like the moist mash better than that not moistened, and will eat more of it in a short time. There is no danger from the free use of the properly made mash twice a day, and since it is already ground the young birds can eat and digest more of it than when the feed is all coarse. This is a very important fact, and should be taken advantage of at the time when the young chicks are most susceptible to rapid growth, but the development must be moderate during the first few weeks. The digestive organs must be kept in normal condition by the partial use of hard feed, and the gizzard must not be deprived of its legitimate work and allowed to become weak by disuse.

By the time the chicks are 5 or 6 weeks old the small broken grains are discontinued and the two litter feeds are wholly of screened cracked corn and whole wheat. Only good clean wheat that is not sour or musty should be used.

When young chicks are fed as described, the results have always been satisfactory if the chicks have not been given too much of the scratch feed and if the dishes of ground material have been removed immediately after the meal was completed. The objections to this system of feeding are the extra labor involved in preparing the eggs, mixing the feed with water, and removing the troughs at the proper time.

Method 2.—This is like Method 1, except that fine beef scrap is used instead of boiled eggs and the mash is not moistened.

Early in the morning the chicks are given the hard feed on the floor litter as described in Method 1. At 9 o'clock they are fed a mixture having the following composition:

	Parts by weight.
Rolled oats	2
Wheat bran	2
Corn meal	2
Linseed meal	½
Screened beef scrap	1

This is given in the plates or troughs, and the dishes are removed after ten minutes' use.

At 12.30 the hard grains are fed again, and at 4.30 or 5 the dry-meal mixture is given to them for half an hour or left until their bedtime. The meal being dry, the chicks can not eat it as readily as they can the egg and rolled oats or the moistened mash. For that reason it is left for them to feed upon longer than when moistened with the egg and water, but is never left before them more than ten minutes at the 9-o'clock feeding time. The aim is to give them enough at each of the four meals so that their desire for food may be satisfied at the time, but to make sure that they have nothing left to lunch upon. It is desired to have their crops empty of feed before feeding them again. When treated in this way they will have sharp appetites when the feeder appears, and come racing out from the brooder to meet him. If they have been overfed at the previous meal, and have lunched when they saw fit, they do not care for the feeder's coming. If overfed a few times the creatures become debilitated and worthless.

What has been said so far is with reference to chicks that are hatched out in early spring, at a season of the year when it is impossible under the climatic conditions in Maine for them to get out of doors for work.

Method 3.—This is like Method 2, except that the first mash for the young chicks has the following composition:

	Parts by weight.
Wheat bran	4
Corn meal	3½
Linseed meal	½
Screened beef scrap	2
Alfalfa meal	1

This mixture is scalded and then dry rolled oats are mixed with it in the proportion of 2 parts rolled oats to 6 parts of the mixture. The reason for mixing in this way is that it has been found by experience that if rolled oats are mixed with the other materials of the mash before scalding there is a tendency for the mash to be soggy after it is wet. Mixing in the way here outlined has been found to improve the mash greatly.

This mash and the dry grains are fed as in Method 2 until the chicks are about 3 weeks old. From 3 weeks on to 6 or 8 weeks the composition of the mash is as follows:

	Parts by weight.
Wheat bran	2
Corn meal	3
Linseed meal	½
Daisy flour	1
Beef scrap	1

Method 4.—When warm weather comes and the later-hatched chicks are able to get out on the ground they find much to amuse them, and they work hard and are able to eat and digest more feed. Under these conditions the dry-meal mixture described in Method 2 is kept constantly before them in troughs, with good results. With two feeds a day of the broken grains in the litter they have hard feed enough to insure health and they can safely peck away at the dry-meal mixture—a mouthful or two at a time—when they seem to happen to think of it, and thrive. This method has been considerably used in feeding April and May hatched chicks. Many times the results

from it have been good. At other times, when the weather was dark and raw out of doors and the little things were held inside, they would hang around the troughs and overeat. They would grow rapidly for a few days, then commence to go lame, eat little, and seek the warm hover never to recover.

Method 5.—This consists in feeding the cracked corn, cracked wheat, pin-head oats, and millet seed in the litter four times a day, and keeping a trough of fine beef scrap within reach all the time. Sometimes commercial chick feeds have been used instead of the cracked corn, wheat, oats, and millet. By this system the losses of birds have been small when the feeding has not been so liberal as to clog the appetite. Much care is necessary in adjusting the quantity of feed to the needs of the birds.

Other methods of feeding young chicks have been tried and the results watched. Method 1 has been used for several years and no other has been found that gives better growth or less losses of birds. The only objection to it is the labor required in preparing the feed. In the work of the station Method 3 is now preferred and used. The losses of chicks are small by either of the methods. The labor in Method 2 is considerably less than is required in Method 1. Where either Methods 1, 2, or 3 are used the liability of injury to the chicks is much less than when Methods 4 or 5 are followed.

There are no mysteries connected with the raising of the young chickens. Every chick that is well hatched out by the twenty-first day of incubation should live, and will do so as a rule if kept dry, at reasonable temperatures, and not allowed to overeat.

The most careful work of the poultryman during the whole year is required in getting the chicks through the first three weeks of their lives successfully. If they are vigorous up to the fourth week, there is little liability of injuring them thereafter by any system of feeding, if it is only generous enough and they have their liberty.

FEEDING CHICKENS ON THE RANGE.

By the middle of June the chickens that were hatched in April are being fed on cracked corn, wheat, and the mash. At about that time the portable houses containing the chickens are drawn from their winter locations out to an open hayfield where the crop has been harvested and the grass is short and green. If not too much worn, the same field may be used a second season for chickens, but this is not recommended. A new, clean piece of turf land should be used each year. Two acres should be allowed for each 1,000 chickens.

When the chickens are moved to the range, the sexes are separated. The methods of feeding the cockerels and pullets differ, and there has been a gradual change in the methods of feeding. Each method has given good results. The changes have been introduced to save labor. After the chickens were moved to the range they were fed in the morning and evening with a moistened mixture of corn meal, middlings, and wheat bran, to which one-tenth as much beef scrap was added. The other two feeds were of wheat and cracked corn.

In 1904 a change was made in the manner of feeding 1,400 female chickens by omitting the moist mash and keeping in separate slatted troughs cracked corn, wheat, beef scrap, cracked bone, oyster shell, and grit where they could help themselves whenever they desired to do so. Grit, bone, oyster shell, and clean water were always supplied. There were no regular hours for feeding, but care was taken that the troughs were never empty.

In 1905 another trough containing a dry mash consisting of 1 part wheat bran, 2 parts corn meal, 1 part middlings, and 1 part beef scrap was used in addition to those containing the grains. The results were satisfactory. The labor of feeding was far less than that required by any other method tried. The birds did not hang around the troughs and overeat, but helped themselves, a little at a time, and ranged off, hunting or playing, and coming back again to the food supply at the troughs when so inclined. There was no rushing or crowding about the attendant, as is usual at feeding time where large numbers are kept together. While the birds liked the beef scrap, they did not overeat of it. During the range season, from June to the close of October, the birds ate just about 1 pound of the scrap to 10 pounds of the cracked corn and wheat. This is practically the proportion eaten when the moist mash was used.

THE FEEDING TROUGH.

The difficulty of keeping the feed clean and dry during continued exposure is nearly overcome by using troughs with slatted sides and broad, detachable roofs (figs. 2 and 3). The troughs are from 6 to 10 feet long, with the sides 5 inches high. The lath slats are 2 inches apart, and the troughs are 16 inches high from floor to roof. The roofs project about 2 inches at the sides and effectually keep out the rain except when high winds prevail.

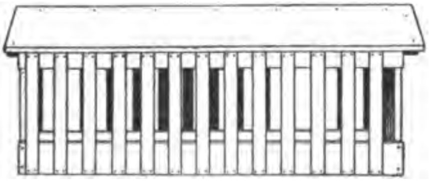
FIG. 2.—Chicken feeding trough, accessible from both sides, with cover on.

The roof is very easily removed by lifting one end and sliding it endwise on the opposite gable end on which it rests, as shown in figure 3. The trough can then be filled and the roof drawn back into place without lifting it. This arrangement is economical of feed, keeping it in good condition and avoiding waste. When dry mash is used there may be considerable waste by the finer parts being blown away, and on this account the dry-mash trough should be put in a sheltered place out of the reach of wind.

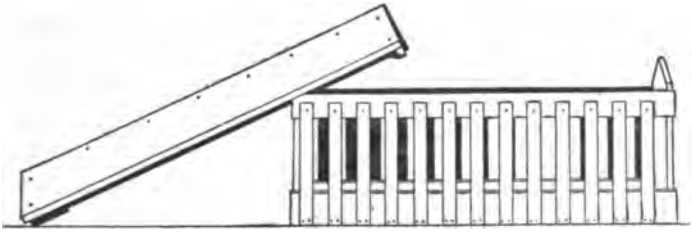

FIG. 3.—Chicken feeding trough with cover removed.

FEEDING THE COCKERELS FOR MARKET.

At the Maine station most of the cockerels are to be used for breeding purposes, and they are fed in flocks of about 100 on the range in about the same way as the pullets. The dry-feed method is now used for them as satisfactorily as for the pullets.

A very large proportion of the cockerels raised in New England are sent to the market alive, without being fattened. Quite extended experiments at the Maine station with many birds in different years indicate very clearly that keeping the cockerels for a few weeks with special feeding will add materially to the selling price. Not infrequently this will make the difference between loss from the low price obtained for slow-selling unfattened birds and the profit from comparatively quick-selling specially fed birds at a much higher price. The higher price is due partly to the increased weight and partly to the superior quality of the well-covered soft-fleshed chickens. As the bulletins containing the results of these feeding experiments with cockerels are out of print, the following brief summary of the results obtained is given:

The number of pounds of grain required to produce 1 pound of gain in fattening cockerels was ascertained in experiments comparing (1) the effect of housing, (2) the effect of age, and (3) the effect of skim milk. The grain mixture used in these series of experiments was the same, consisting of 100 pounds of corn meal, 100 pounds of wheat middlings, and 40 pounds of meat meal. This was fed as a porridge thick enough to drop but not to run from a spoon.

The French and English fatteners who make a specialty of the business, fattening thousands of chickens each year, confine the chickens in small coops. The coops used at the Maine station gave a floor space of 16 by 23 inches, in each of which 4 chickens were placed. The coops were constructed of laths with closed-end partitions of boards. The floors, sides, and tops were of laths placed three-quarters of an inch apart. By simply moving the pens thus constructed the floors were kept clean. V-shaped troughs with 3-inch sides were placed in front and about 2 inches above the level of the floors of the coops. Cockerels thus fed were compared with others kept in small houses 9 by 11 feet in size, with an attached yard 20 feet square. The yard was entirely free from anything that would serve as green feed. Twenty birds were put in each of these houses. As a result of experiments with fattening 286 birds it was found that on the average 7.9 pounds of grain were required to produce 1 pound of gain in the case of birds fed in the coops, and 5.9 pounds in the case of those fed in the small houses and yards.

An experiment with 150 birds when they were 4 months old showed that they required 4.9 pounds of grain to produce 1 pound of gain, while birds from the same stock, when they were 6 months old, required 7.4 pounds of grain to produce 1 pound of gain.

An experiment with 68 birds showed that when the porridge was wet with skim milk only 4.3 pounds of grain were required to produce 1 pound of gain, against 5.3 pounds when the porridge was wet with water. Eight pounds of skim milk was used with each pound of grain.

These experiments warrant the following conclusions: (1) As great gains are made just as cheaply and more easily when the chickens are put into small houses and yards as when they are fed in small lots in lattice coops just large enough to hold them. (2) Four weeks is about the limit of profitable feeding, both individually and in flocks. (3) Chickens gain faster while young. Birds that are from 150 to 175 days old have uniformly given comparatively small gains. (4) The practice of successful poultrymen selling chickens at the earliest marketable age is well founded. The spring chicken sold at Thanksgiving time is an expensive product.

The experiments clearly indicate that it is profitable to fatten chickens in cheaply constructed sheds or in large coops with small runs for about four weeks and then send them to market dressed. In quality the well-covered, soft-fleshed chickens are so much superior to the same birds not specially prepared that the former will be sought for at a higher price. The dairy farmer is particularly well prepared to carry on this work, as he has the skim milk which these experiments show to be of so great importance in obtaining cheap rapid growth and superior quality of flesh.

HOUSING THE HENS.

When work in poultry management was first undertaken at the University of Maine, the hens were kept in small colonies in accord with what was at that time believed to be the best practice. Houses

10 feet square were erected with the idea of accommodating about 15 birds each. Although the houses were well warmed they were apt to be damp and lined with white frost in very cold weather, when the windows had to be kept shut to protect the birds from cold at night. Another disadvantage of this kind of house is its small size. A person can not care for hens in such small pens without getting them into a condition of unrest for fear of being cornered in such a small room. The question of extra labor in caring for hens in these small colonies scattered over quite a large area is an important factor in a commercial plant. When the Maine station began experiments in 1897 a warmed house 150 feet long by 16 feet wide was erected. As before mentioned, this house was burned the next spring, but was replaced by another of the same kind. This warmed house, while constructed after the most approved model of the time, has never been a satisfactory house for laying hens. In recent years it has been used only for the keeping of surplus stock and for carrying cockerels over the winter. It has now been abandoned entirely in favor of curtain-front houses to be described below.

THE ROOSTING-CLOSET HOUSE.

Seven years ago one of the 10-foot square houses described above was taken for a nucleus and an addition made, so that the reconstructed house was 10 feet wide and 25 feet long. The inside end of the old house was taken out, so that there is one room with a floor space of 250 square feet. The walls are about 5½ feet high in the clear inside of the building. The whole of the front wall is not filled in, but a space 3 feet wide and 15 feet long is left just under the plate. This space had a frame covered with white drilling, hinged at the top on the inside, so it can be let down and buttoned during driving storms and winter nights, but hung up out of the way at all other times. The cloth of the outer curtain is oiled with hot linseed oil. The roost platform extends the whole length of the back of the room. It is 3 feet 4 inches wide and 3 feet above the floor. The back wall and up the roof for 4 feet is lined and the space filled and packed hard with fine hay. The packing also extends part way across the ends of the room.

Two roosts are used, but they do not take the whole length of the platform, a space of 4 feet at one end being reserved for a crate where broody hens can be confined until the desire for sitting is overcome. The space, from the front edge of the platform up to the roof, is covered by frame curtains of drilling, similar to the one on the front wall, except that it is not oiled. They are hinged at the top edge and kept turned up out of the way during daytime, but from the commencement of cold weather until spring they are closed down every night after the hens go to roost. The hens are shut in this close roosting closet and kept there during the night, and are released as early in the morning as they can see to scratch for the grain which is sprinkled in the 8-inch deep straw on the floor.

The roosting closet has been closely observed and has never been damp or its odors offensive when opened in the mornings. There was very little freezing in the closets in the coldest weather. The birds seemed to enjoy coming out of the warm sleeping closet down into the cold straw, which was always dry, because the whole house was open to the outside air and sun every day. There were no shut-off corners of floor or closet that were damp.

This building was used through five winters with 50 hens in it. The birds laid as well as the others in the large warmed house; their combs were red and their plumage bright, and they gave every evidence of perfect health and vigor. While they were on the roosts they were warm. They came down to their breakfasts and spent the day in the open air. Such treatment gives vigor and snap to the human being, and it seems to work equally well with the hen.

This house was given the name of the "pioneer" house.

CURTAIN-FRONT HOUSES.

The result of the use of the "pioneer" house indicated that this was a correct system of treating and housing hens, and it was decided to build several houses on the same plan and join them together under one roof as one house.

A curtain-front house 12 feet wide by 150 feet long, known as house No. 2, was erected in 1903. The back wall is 5 feet 6 inches high from floor to top of plate inside, and the front wall is 6 feet 8 inches high. The roof is of unequal span, the ridge being 4 feet in from the front wall; and the height of the ridge above the floor is 9 feet. The sills are 4 by 6 inches in size and rest on a rough stone wall laid on the surface of the ground. A central sill gives support to the floor, which at times is quite heavily loaded with sand. The floor timbers are 2 by 8 inches in size and are placed 2 feet apart; the floor is of two thicknesses of hemlock boards. All the rest of the frame is of 2 by 4 inch stuff. The building is boarded, papered, and shingled on roof and walls. The rear wall and 4 feet of the lower part of the rear roof are ceiled on the inside of the studding and plates, and the space between inner and outer walls is packed very hard with dry sawdust. In order to make the sawdust packing continuous between the wall and roof, the wall ceiling is carried up to within 6 inches of the plate; then follows up inclining pieces of studding to the rafters, the short pieces of studding being nailed to the studs and rafters. By this arrangement there are no slack places around the plate to admit cold air. The end walls are packed in the same way. The house is divided by close-board partitions into seven 20-foot sections; one 10-foot section is reserved at the lower end for a feed-storage room.

Each of the 20-foot sections has two 12-light outside windows screwed onto the front, and the space between the windows (which is 8 feet long) for a distance of 3 feet down from the plate is covered during rough winter storms and cold nights by a light frame covered with 10-ounce duck, oiled and closely tacked on. This door, or curtain, is hinged at the top and swings in and up to the roof when open.

In the front of each section is a door 2 feet 6 inches wide. The roost platform is at the back of each room and extends the whole 20 feet. The platform is 3 feet 6 inches wide and 3 feet above the floor. The roosts are of 2 by 3 inch stuff placed on edge and are 10 inches above the platform. The back one is 11 inches out from the wall, and the space between the two roosts is 16 inches, leaving 15 inches between the front roost and the duck curtain, which is sufficient to prevent the curtain being soiled by the birds on the roost. The two curtains in front of the roost are similar to the one in the front of the house, except that they are not oiled. They are each 10 feet long by 30 inches wide, hinged at the top, and open into the room and fasten up when not in use. Great care was exercised in constructing the roosting closets to have them as nearly air-tight as possible, except as air might come in through the cloth curtain.

Single pulleys are hung at the rafters, and by means of a rope fastened to the lower edge of the curtain frames it is easily raised or lowered and kept in place.

Six trap nests are placed at one end of each room and four at the other. They are put near the front so that the light may be good for reading and recording the numbers on the leg bands of the birds. Several shelves are put on the walls 18 inches above the floor for shell, grit, bone, etc. The doors which open from one room to another throughout the building are frames covered with 10-ounce duck, so as to make them light, and are hung with double-action spring hinges. The advantages of having all doors push from the person passing through are very great; otherwise they would hinder the passage of the attendant with his baskets and pails. Strips of old rubber belting are nailed around the studs which the doors rub against as they swing to, so as just to catch and hold them from being opened by the wind. Tight board partitions are used between the pens instead of wire, so as to prevent drafts. An outside platform 3 feet wide extends across both ends and the entire front of the building.

This house accommodates 350 hens—50 in each 20-foot section—is well made of good material, and should prove to be durable. A rougher building, with plain instead of trap nests, and with the roof and walls covered with some of the prepared materials instead of shingles, could be built for less money, and would probably furnish as comfortable quarters for the birds. The interior of one section of this house is shown in figure 4.

Curtain-front house No. 3 was constructed in 1904. It is 16 feet wide by 120 feet long, and is of the same style as No. 2, except that it is wider. There are four pens in the building; each 16 feet wide by 30 feet long. Two of the pens are arranged for 100 hens each, and two for 150 each. For the 150 hens three roosts instead of two are required.

The cloth-covered fronts of the closets where 100 and 150 hens roost are of the same size, and it became evident early in the first winter that the supply of fresh air to the largest flock was not sufficient. It was not practicable to increase materially the cloth surface and allow more air to filter in, so three openings were made in the upper part of the curtain frame, through which better ventilation could be secured. The openings are 6 inches wide by 30 inches long and are provided with wooden shutters. These are kept wide open into the outer room during mild nights, but when high winds prevail and the temperature falls to 10 or more degrees below zero the openings are half closed.

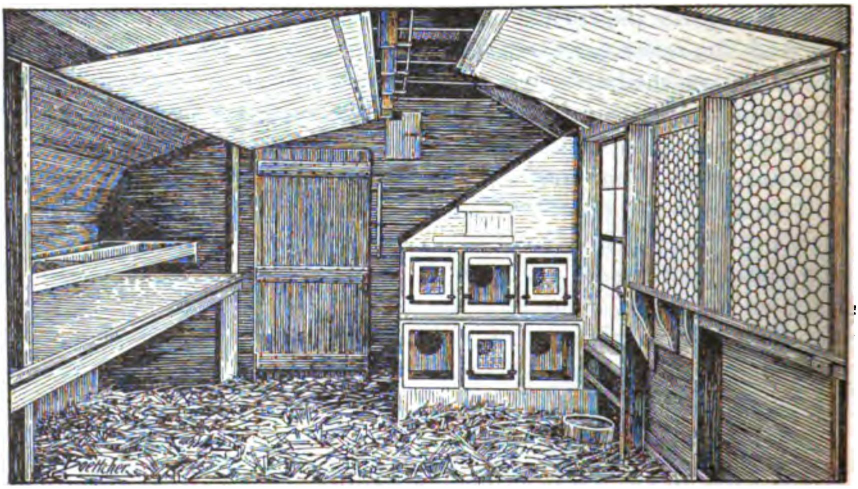

FIG. 4.—Interior of curtain-front poultry house No. 2.

The walls of the elevated closet are packed with sawdust 4 inches in thickness, and the curtains fit very closely, leaving only small cracks. The 10-ounce duck of which the curtains are made is not oiled. The supply of fresh air is mostly admitted through the cloth, while the breathed warmer air passes off through the openings above. By this arrangement the birds are not in drafts or currents of air. Where three roosts are arranged abreast, instead of two, the openings are absolutely essential, and for smaller flocks they are convenient during the mild nights, especially toward spring.

The latest form of curtain-front house.—During the summer of 1905 the management of a commercial poultry plant in Orono built a curtain-front house to accommodate 2,000 laying hens. This was built in accordance with unpublished plans prepared by the Maine Experiment Station. The description is here given, as it represents the latest development of this style of house. The appearance of the house as a whole is shown in figure 5.

The house is 20 feet wide by 400 feet long, and is divided into 20 sections, each being 20 feet square. It is on the same general plan as houses Nos. 2 and 3 just described, but house No. 2 is 12 feet wide, house No. 3, 16 feet wide, and this one 20 feet wide. The widths have been increased in the last two houses, as experience has shown the advisability of it. At first it was thought the houses should be narrow so they might dry out readily, but the 20-foot house dries out satisfactorily, as the opening in the front is placed high up so that the sun shines in on the floor to the back in the shortest winter days.

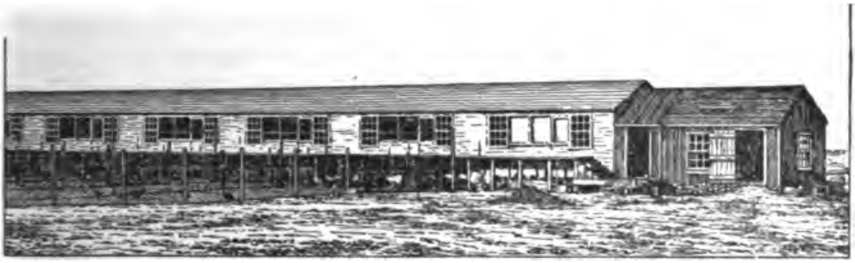

FIG. 5.—The latest curtain-front poultry house.

The economy in the cost of the wide house over the narrow ones, when space is considered, is evident. The front and back walls in the narrow house cost about as much per linear foot as those in the wide house, and the greatly increased floor space is secured by building in a strip of floor and roof running lengthwise of the building. The carrying capacity of a house 20 feet wide is 66 per cent greater than that of a house 12 feet wide, and it is secured by merely building additional floor and roof. The walls, doors, and windows remain the same as in the narrow house, except that the front wall is made a little higher. Three sills, which are 6 inches square, run lengthwise of the house, the central one supporting the floor timbers in the middle. They rest on a rough stone wall, high enough from the ground for dogs to go under the building to look after rats and skunks that might incline to make their homes there. The stone wall rests on the surface of the ground, and there are openings in it like cellar windows, every 20 feet, to allow the air to draw through and keep the basement dry during the summer. The floor timbers are 2 by 8 inches in size and rest wholly on top of the sills. All wall studs rest on the sills; the front ones are 8 feet long, and the back ones 6 feet 6 inches long. The two sides of the roof are unequal in width, the ridge being 8 feet from the front wall. The height of the ridge from the sill to the extreme top is 12 feet 6 inches. All studding is 2 by 4 inches in size and the rafters are 2 by 5 inches. The building is boarded with 1-inch boards, and is papered and shingled with good cedar shingles on walls and roof. The floor is of two thicknesses of hemlock boards which break joints in the laying.

The building is divided by tight board partitions into twenty sections, each section being 20 feet long. All of the sections are alike in construction and arrangement. The front side of each section has two storm windows of twelve lights of 10 by 12 inch glass. These windows are screwed on upright and 2 feet 8 inches from each end of the room; they are 3 feet above the floor. The distance between the windows is 8 feet 10 inches, and the top part of it to a depth of 3 feet 6 inches from the plate is not boarded but is left open to be covered by the cloth curtain when necessary. This leaves a tight wall 3 feet 10 inches high extending from the bottom of the opening down to the floor, which prevents the wind from blowing directly on the birds when they are on the floor. A door is made in this part of the front wall for the attendant to pass through when the curtain is open. A door 16 inches high by 18 inches wide is placed close to the floor under one of the windows for the birds to pass through to the yards in front. A similar door is in the center of the back wall to admit them to the rear yard when it is used.

A light frame made of 1 by 3 inch pine strips and 1 by 6 inch crossties is covered with 10-ounce white duck and hinged at the top of the front opening, which it covers when closed down. This curtain is easily turned up into the room, where it is caught and held by swinging hooks until released.

The roost platform is made tight and extends along the whole length of the room against the back wall. It is 4 feet 10 inches wide and 3 feet above the floor, being high enough for a person to get under it comfortably when necessary to catch or handle the birds. There are three roosts framed together in two 10-foot sections. The tops of the roosts are 1 foot above the platform and hinged to the back wall, so they may be turned up out of the way when the platform is being cleaned. The back roost is 12 inches from the wall, and the spaces between the next two are 16 inches. They are made of 2 by 3 inch spruce lumber placed on edge with the upper corners rounded off.

The roosting closet is shut off from the rest of the room by curtains similar to the one described above. For convenience in handling there are two of these curtains, each 10 feet long. They are 3 feet wide and are hinged at the top so as to be turned out and hooked up. The space above this curtain is ceiled and in it are two openings each 3 feet long and 6 inches wide for ventilating the roosting closet when necessary. In every compartment there is a door placed 5 inches out from the edge of the roost platform. These doors are 3 feet wide and 7 feet high, divided in the middle lengthwise, and each half is hung with double-acting spring hinges, allowing it to swing open both ways and close.

Ten nests are placed in two tiers against the partition in each end of the room. They are of ordinary form, each nesting space being 1 foot wide, 1 foot high, and 1 foot long, with the entrances near the partition, away from the light, and with hinged covers in front for the removal of the eggs. Each section of 5 nests can be taken out without disturbing anything else, cleaned, and returned. In constructing the house it was designed to use these nests only during the first year. The framework where they rest was arranged for the use of trap nests, which were installed in October, 1906.

Troughs similar to those described on page 18 are used for feeding dry mash, shell, bone, grit, and charcoal.

Two lines of 4 by 4 inch spruce are arranged as an elevated track above the doors. The track extends the entire length of the building, and being faced with narrow steel bands on top, a suspended car is readily pushed along, even when heavily loaded. The car platform is 2 by 8 feet in size, and is elevated a foot above the floor. All feed and water are carried through the building on this car. Ten iron baskets, into which the accumulations on the roost platforms are cleaned every morning, are put on the car, and collections are made as the car passes on through the pens to the far end of the building, 400 feet away, where the roost cleanings are dumped into the manure shed. As the car is pushed along a guard at the front end comes in contact with the doors and pushes them open, and they remain open until the car has passed on, when the spring hinges force them to close again. This car is a great saver of labor, as it does away with nearly all carrying by the workmen. It has enabled one man to take good care of the 2,000 hens from November to March, except on Saturdays, when the litter was removed and renewed by other men.

At one end of the building there is a temporary feed and water house, also used for dish washing and scalding, where the car remains when not in use.

There is a walk outside of the building, extending along its entire front. It is 4 feet wide, made of 2-inch plank, and is elevated 2 feet above the floor of the building, which allows the doors below it, through which the birds pass to the front yards, to be opened and closed without interference. The door which opens out of each room

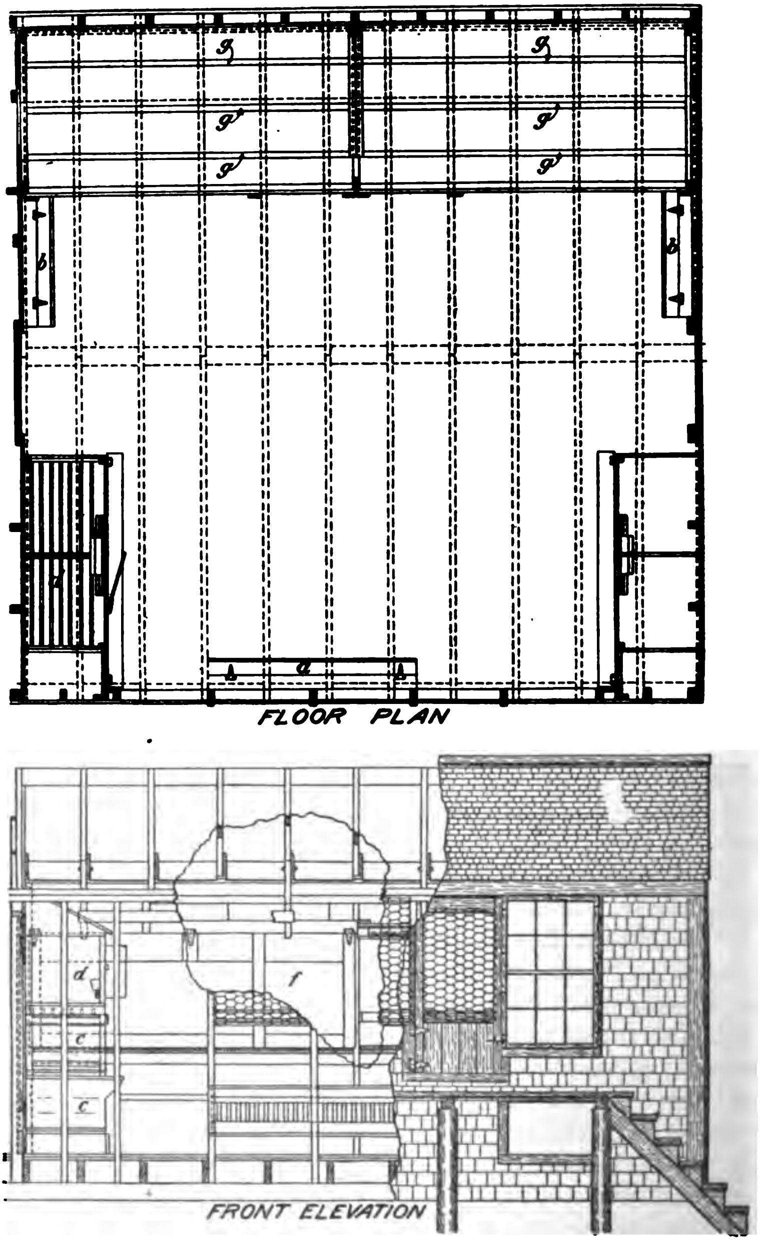

FIG. 6.—Floor plan and front elevation of section of latest curtain-front poultry house. *a*, Feed trough for dry mash; *b*, feed trough for grit, bone, etc.; *c*, trap nest; *d*, coop for broody hens; *e*, front curtain; *f*, roosting closet curtain; *g*, roost bars; *h*, small closet in which eggs taken from nest are placed.

through the curtain section is above the outside walk and necessitates stepping up or down when passing through, which is not a very serious objection, as the door is used but little in the daily work, but mostly in the weekly cleaning out and renewing of the floor litter. A guard of wire poultry netting 1 foot wide along the outside of the walk prevents the birds from flying from the yards up to the walk. The advantage of the elevated walk over one on a level with the sill of the building is that it is unobstructed by gates, which, were the low walk used, would be necessary to prevent the birds passing from one yard to another.

Detailed working drawings and specifications for one section or unit of this curtain-front house follow. From these data anyone can figure what will be the cost of building one of these houses of any desired length at the prices of building material current in his locality.

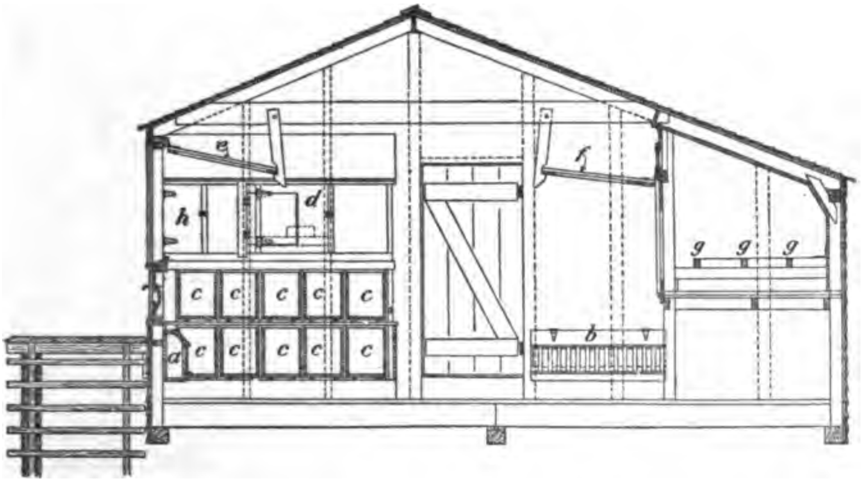

FIG. 7.—End elevation (inside) of latest curtain-front poultry house. (For key to letters, see fig. 6.)

Material needed for a unit of curtain-front house:

LUMBER.

(Spruce is specified simply because that is the material actually used in the building described. Any other equally strong lumber may be used. Amounts are given in board feet unless otherwise specified.)

The following estimates do not allow for waste in cutting.

8 cedar posts, 6 feet long, 6-inch butts.
350 feet 2 by 4 inch spruce for studs, door, window, and coop frames.
650 feet 2 by 8 inch plank for floor joists, outside walk, etc.
180 feet 6 by 6 inch spruce for sills.
26 feet 4 by 4 inch spruce for corner studs and wall stringers.
40 feet 2 by 3 inch spruce for roosts, etc.
215 feet 2 by 5 inch spruce for rafters.
39 feet 2 by 9 inch spruce for steps.
12 feet 2 by 6 inch spruce for step frames.

110 feet 1 by 8 inch boards, spruce, for braces for rafters.
38 feet 1 by 9 inch boards, spruce, for doors.
10½ feet per door 6-inch boards, spruce, for door braces.
2,300 feet boards, spruce or hemlock, for outside boarding, walls, floor, roof, etc.
100 feet boards, spruce, for roost frames.
40 linear feet 2 by 2 inch spruce planed to 1¾ by 1¾ inches.
6 feet 2 by ¾ inch spruce.
55 feet spruce boards for feed and grit troughs.
50 feet pine for curtain frames.
20 laths.
6,000 cedar shingles.

HARDWARE.

1 pair double-acting spring hinges with screws.
1 pair 6-inch heavy T hinges with screws.
7 pairs 5-inch light T hinges with screws.
4 pairs 3-inch light T hinges with screws.
2 pairs 2 by 2 inch butts with screws.
5 pairs 3 by 3 inch butts with screws.
2 dozen No. 10 screws 2 inches long.
20 pounds 3-penny shingle nails.
75 pounds 8-penny common nails.
25 pounds 10-penny common nails.
10 pounds 20-penny common nails.
2 pounds 3-penny clinch nails.
1 pound ¾-inch staples.
2 thumb latches complete with screws.

MISCELLANEOUS.

2 storm windows, 12 lights, 10 by 12 inch glass.
6 squares building paper.
10 feet 42-inch poultry netting.
3 yards 42-inch, 10-ounce duck.
7 yards 30-inch, 10-ounce duck.

Advantages of curtain-front houses.—The "pioneer" house was in use for five years with 50 pullets in it each year; the No. 2 house has been in use five years with 300 pullets each year, the No. 3 house four years, and the house last described three years. Besides these four houses, the Maine station has had the use of another house of the open-front style of construction for six years with about 200 1-year-old breeding hens in it each year.

Maine is subject to long spells of severe cold weather, with the temperature considerably below zero at night, and about zero during the day, and with a good deal of high wind. During such rough weather the bedding on the floor has kept comparatively dry; and the voidings on the platform, when the curtains are raised in the mornings, have been but slightly frozen. The yields of eggs during severe weather and immediately following it are rarely below those immediately preceding it. It should be borne in mind that had the weather been mild all that time the hens probably would have increased in production rather than remained stationary. They are doubtless affected by the severe weather, but not seriously, as they uniformly begin to increase in production very soon after the weather becomes normal for midwinter.

These curtain-front houses have all proved eminently satisfactory. Not a case of colds or snuffles has developed from sleeping in the warm elevated closets, with their cloth fronts, and then going directly down into the cold room, onto the dry straw, and spending the day in the open air. The egg yields per bird have been as good in these houses as in warmed ones. The purpose of having rooms and flocks of different sizes was to compare the welfare and egg yields of the birds under the different conditions.

THE YARDS.

The yards to most poultry houses are at the south, or on the sheltered sides of the buildings, to afford protection during the late fall and early spring, when cold winds are common. The warmed house had yards on both north and south sides, with convenient gates. The south yards were used until the cold winds were over in spring, when the hens were allowed to go to the north yards, which were well set in grass sod. With the curtain-front houses the yards need be on the north side only. The birds are kept in the building until the weather is suitable for opening the small doors in the rear wall. The necessity for getting them out of the open-front house, where they are really subject to most of the out-of-door conditions during the daytime, is not so great as when they are confined in closed houses with walls and glass windows. The clear, open fronts of the curtain-front houses allow teams to pass close to the open door of the pens for cleaning out worn material and delivering new bedding, and also allow attendants to enter and leave all pens from the outside walk and reach the feed room without passing through intervening pens.

FEEDING THE HENS.

For about twenty-five years the same family of Barred Plymouth Rocks has been carried at the University of Maine, and one way has been learned to feed and handle them to secure eggs and to avoid the losses from overfatness, which are so common to mature hens of that breed. It is not claimed or thought that the methods of feeding here given are ideal; other methods may be as good or even better. These methods have, however, given good results at the Maine station. While it is true that only the full-fed hen can lay to the limit of her capacity, it is equally true that full feeding of the Plymouth Rocks, unless correctly done, results disastrously.

Years ago the "morning mash," which was regarded as necessary to "warm up the cold hen," so she could lay that day, was given up.

The method of feeding now employed is in detail as follows: Early in the morning for each 100 hens 4 quarts of whole corn is scattered on the litter, which is 6 to 8 inches deep on the floor. This is not mixed into the litter, for the straw is dry and light, and enough of the grain is hidden so the birds commence scratching for it almost immediately. At 10 o'clock they are fed in the same way 2 quarts of wheat and 2 quarts of oats. This is all of the regular feeding that is done.

The use of corn and corn meal as major parts of the feed of hens kept for egg production has been very generally condemned by poultrymen and farmers, until it is now used only as a very minor part of the ration for the fear that its use will cause overfatness and interfere with egg making. When used more freely and made a prominent factor in the ration it has been thought best to have the kernels broken, so that in hunting and scratching for the small pieces the birds might get the exercise needed to keep themselves in health and vigor. It was reasoned that even a small quantity of whole corn could be readily seen and picked up from the straw litter with little exertion, and that the vices of luxury and idleness would follow. In order to test this view an experiment was carried out at the station in the winter of 1906–7 in which whole corn was substituted for cracked corn in the ration of 500 laying pullets. A control lot of 500 received cracked corn. All other conditions affecting the two lots were kept as nearly identical as possible. The result of the experiment was that there was no appreciable difference in regard to either egg production, health, or general well-being between the two flocks of birds.

Besides the dry whole grain a dry mash is kept always before the birds. Along one side of the room is the feed trough with its slatted front, and in it is kept a supply of dry meals mixed together. This dry-meal mixture or mash has the following composition:

	Parts by weight.
Wheat bran	2
Corn meal	1
Middlings	1
Gluten meal or brewers' grains	1
Linseed meal	1
Beef scrap	1

These materials are spread on the floor in layers one above another and shoveled together until thoroughly mixed, then kept in stock for supplying the trough. The trough is never allowed to remain empty.

The dry-meal mixture is constantly within reach of all of the birds, and they help themselves at will.

Oyster shell, dry cracked bone, grit, and charcoal are kept in slatted troughs, and are accessible at all times. A moderate supply of mangolds and plenty of clean water is furnished. About 5 pounds of clover hay cut into ½-inch lengths is fed dry daily to each 100 birds in winter. When the wheat, oats, and cracked corn are given, the birds are always ready and anxious for them, and they scratch in the litter for the very last kernel before going to the trough where an abundance of feed is in store.

It is very evident that the hens like the broken and whole grains better than the mixture of the fine, dry materials; yet they by no means dislike the latter, for they help themselves to it, a mouthful or two at a time, whenever they seem to need it, and never go to bed with empty crops, so far as noted. They apparently do not like it well enough to gorge themselves with it, and sit down, loaf, get overfat, and lay soft-shelled eggs, as is so commonly the case with Plymouth Rocks when they are given warm morning mashes in troughs.

Some of the advantages of this method of feeding are that the mash is put in the troughs at any convenient time, only guarding against an exhaustion of the supply, and the entire avoidance of the mobbing that always occurs at trough feeding when that is made a meal of the day, whether it be at morning or evening. There are no tailings to be gathered up or wasted, as is common when a full meal of mash is given at night. The labor is very much less, enabling a person to care for more birds than when the regular evening meal is given.

For green feed during winter and spring mangolds are used. They are liked by the birds, and when properly harvested and cared for remain crisp and sound until late spring. They are fed whole, by sticking them onto projecting nails about a foot and a half above the floor. Care must be exercised in feeding them, as they are a laxative when used too freely. On the average about a peck per day to 100 hens can be safely used. They would eat a much greater quantity if they could get it.

The average amounts of the materials eaten by each hen during the last year are about as follows:

	Pounds.
Grain and the meal mixture	90.0
Oyster shell	4.0
Dry cracked bone	2.4
Grit	2.0
Charcoal	2.4
Clover	10.0

A POULTRY-HOUSE DISINFECTANT.

There can be no doubt that one absolutely necessary supply about every well-conducted poultry plant must be some sort of disinfecting solution. Furthermore, such a disinfectant ought to fulfill satisfactorily several requirements. In the first place, it must be inexpensive. Further, it must be powerful and certain in its action even in dilute solutions. Finally, it must be of such a character as not to injure the birds if it, by accident or design, comes in contact with them. There are a great many commercial disinfectants on the market. Some of the most successful and widely used of these have either a phenol (carbolic acid) or a cresol base. Many of these preparations are excellent and their excellence is attested by their very wide popularity among poultrymen. There is one objection, however, to all of them; that is, that they are relatively expensive. The farmer or poultryman who uses them pays a good round price for the manufacture of something which he could manufacture himself, the only cost in that event being the cost for the raw materials.

The station has carried on a number of experiments with disinfectants to find a material well suited to the needs of the poultryman which should at the same time be cheap and easy to manufacture. As a result of these experiments the conclusion has been reached that, on the whole, cresol is an excellent substance for poultry-house disinfection. Experiments of the Department of Agriculture [a] have shown that cresol is one of the most powerful germicides and disinfectants known. The experience of the station shows that in addition to the germicidal value of a cresol solution it has a very considerable value as a poultry insecticide. It has even been used with satisfactory results to rid hens of lice by direct spraying of the birds. A very small application in spray was found to rid a bird of lice without harmful effect to the bird itself.[b] Furthermore, in the experience of the station it is, when applied as a spray, very effective in ridding the houses, nests, etc., of lice.

Cresol may be stirred up directly with water and used as a spray. Since cresol is only slightly soluble in water it is better to make use of the "compound solution of cresol" (liquor cresolis compositus) of the United States Pharmacopeia.

Liquor cresolis compositus, or, as it may for convenience be called, cresol soap, may be easily manufactured by any poultryman. The only requisite is a careful attention to the details in the process and a rigid following of the instructions given below. In order to make clear the reasons for the method of manufacture which will be outlined it may be well to give some account of the nature of the substance itself. The active base or cresol soap disinfecting solution is commercial cresol. This is a thick, sirupy fluid varying in color in different lots from a nearly colorless fluid to a dark brown. It does not mix readily with water, and therefore in order to make satisfactorily a dilute solution it is necessary first to incorporate the cresol with some substance which will mix with water and will carry the cresol over into the mixture. The commercial cresol as it is obtained is a corrosive substance, being in this respect not unlike carbolic acid. It should, of course, be handled with great care, and the pure cresol should not be allowed to come in contact with the skin. If it does so accidentally the spot should be immediately washed off with plenty of clean water. The price of commercial cresol varies with the drug market. It can be obtained through any druggist. On the day that this is written the quotation on cresol in the New York market is 24 cents a pound. In purchasing this article one should order simply "commercial cresol."

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[a] McBryde, C. N. The Germicidal Value of Liquor Cresolis Compositus (U. S. P.). Bureau of Animal Industry Bulletin 100, pp. 1-24, 1907.

[b] We do not recommend this method of ridding birds of lice, because of the danger that the bird will take cold as a result of the wetting. This experiment was performed simply to test the value of the cresol solution as an insecticide under the most unfavorable conditions for its action.

The solution or soap referred to is made as follows: Measure out 4 quarts of raw linseed oil in a 4 or 5 gallon stone crock; then weigh out in a dish 1¾ pounds of commercial potassium hydroxid or caustic potash, which may be obtained from any druggist at a cost of from 10 to 15 cents a pound. Dissolve this caustic potash in one pint of water; let it stand for at least three hours until the potash is completely dissolved and the solution is cold; then add the cold potash solution very slowly to the linseed oil, stirring constantly. Not less than five minutes should be taken for the adding of this solution of potash to the oil. For five hours after mixing the oil and potash mixture (soap) should be stirred thoroughly about once every hour and then left standing for ten or twelve hours. By the expiration of that time saponification should be complete. The soap should then be stirred and broken up into small pieces and 5¼ quarts of commercial cresol should be added. The soap will slowly dissolve in this cresol. It may take two days for complete solution to be effected. The length of time taken in dissolving will depend on the condition of the soap, which in turn varies with different lots of linseed oil. When the soap is all dissolved, the solution, which is liquor cresolis compositus or cresol soap, is then ready to use. This cresol soap will mix in any proportion with water and yield a clear solution.

As has been said, cresol soap is an extremely powerful disinfectant. In the station poultry plant for general purposes of disinfecting the houses, brooders, brooder houses, incubators, nests, and other woodwork it is used in a 2 per cent solution with water. Three or four tablespoonfuls of the cresol soap to each gallon of water will make a satisfactory solution. This solution may be applied through any kind of spray pump or with a brush. Being a clear watery fluid, it can be used in any spray pump without difficulty. For disinfecting brooders or incubators which there is reason to believe have been particularly liable to infection with the germs of white diarrhea or other diseases the cresol may be used in double the strength given above and applied with a scrub brush in addition to the spray.

The first consideration in choosing a disinfectant must be its effectiveness. It is a poor sort of economy to use a disinfectant which costs little and will kill few or no germs. Taking into account its effectiveness in dilute solutions, liquor cresolis compositus is believed to be one of the best and cheapest germicides and disinfectants available. The station is using it altogether in its own work and feels justified in recommending it to poultrymen.

TRAP NESTS.

In all the experimental work with laying hens at the Maine station use is made of trap nests. During the past year a new type of trap nest[a] has been devised which is proving extremely satisfactory. The features in which this nest is superior to the type formerly used at the station are (1) certainty and precision of operation; (2) greater simplicity of construction, with less tendency to get out of order and work badly; (3) saving of labor in resetting the nest after use.

The nest is a box-like structure, without front, end, or cover, 28 inches long, 13 inches wide, and 16 inches deep, inside measure. A division board with a circular opening 7½ inches in diameter is placed across the box 12 inches from the rear end and 15 inches from the front end. Instead of having the partition between the two parts of the nest made with a circular hole, it is possible to have simply a straight board partition extending up 6 inches from the bottom, as shown in figure 8. The rear section is the nest proper.

The front portion of the nest has no fixed bottom. Instead there is a movable bottom or treadle which is hinged at the back end (fig. 8). To this treadle is hinged the door of the nest. The treadle is made of ½-inch pine stuff, with 1½-inch hard-wood cleats at each end (figs. 9 and 10) to hold the screws which fasten the hinges. It is 12 inches wide and 12¼ inches long. Across its upper face just behind the hinges holding the door is nailed a pine strip 4 inches wide, beveled on both sides, as shown in figures 9 and 10. The door of the nest is not made solid, but is an open frame (figs. 8 and 10), to the inner side of which is fastened (with staples) a rectangular piece of ⅛-inch mesh galvanized screening (dimensions 8 by 9 inches). The sides of the door are strips of ¾-inch beech stuff 12 inches long and 1½ inches wide, halved at the ends to join to the top and bottom of the door. The top of the door is a strip of hard wood 13 inches long and 1½ inches wide, halved in 2¾ inches from each end. The projecting ends of this top strip serve as stops for the door when it closes (fig. 8). The bottom of the door is a hard-wood strip 10¼ inches by 4 inches. The side strips are fitted into the ends of this bottom strip in such way as to project slightly (about $\frac{1}{32}$ inch) above the front surface of that strip, for a reason which will be apparent.

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[a] While this bulletin was going through the press the writer was informed that a trap nest embodying certain features similar to those in the nest here described was in use at the Utah Agricultural Experiment Station. An examination of the bulletins of that station fails to disclose a description of such a nest. The nest here described was independently devised at the Maine station. Inasmuch as no description of the principle of trap-nest construction here made use of has hitherto been published, it is impossible to make any further acknowledgment of priority in the matter than is contained in the statement here made.

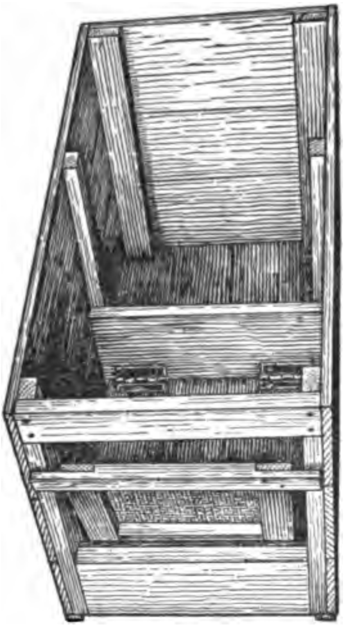
FIG. 8.—Trap nest closed. View from above.

When the nest is open the door extends horizontally in front, as shown in figure 9. In this position the side strips of the door rest on a strip of beech 1½ inches wide, beveled on the inner corner, which extends across the front of the nest. This beech strip is nailed to the top of a board 4 inches wide, which forms the front of the nest box proper. To the bottom of this is nailed a strip 2 inches wide, into which are set two 4-inch spikes from which the heads have been cut (compare fig. 9). The treadle rests on these spikes when the nest is closed. The hinges used in fastening the treadle and door are narrow 3-inch galvanized butts with brass pins, made to work very easily. It is necessary to use hinges which will not rust.

The manner in which the nest operates will be clear from an examination of figures 9 and 10, which show a sample nest with one side removed to show the inside. A hen about to lay steps up on the door and walks in toward the dark back of the nest. When she passes the point where the door is hinged to the treadle her weight on the treadle causes it to drop. This at the same time pulls the door up behind her, as shown in figure 10. It is then impossible for the hen to get out of the nest till the attendant lifts door and treadle and resets it. It will be seen that the nest is extremely simple. It has no locks or triggers to get out of order. Yet by proper balancing of door and treadle it can be so delicately adjusted that a weight of less than half a pound on the treadle will spring the trap. All bearing surfaces are made of beech because of the well-known property of this wood to take on a highly polished surface with wear. The nests in use at the Maine station have the doors of hard wood, in order to get greater durability. Where trap nests are constantly in use, flimsy construction is not economical in the long run. For temporary use the nest door could be constructed of soft wood.

The trap nests are not made with covers because they are used in tiers and slide in and out like drawers. They can be carried away for cleaning when necessary. Four nests in a pen accommodate 20 hens by the attendant going through the pens once an hour, or a little oftener, during that part of the day when the hens are busiest. Earlier and later in the day his visits are not so frequent. The hens must all have leg bands in order to identify them; a number of different kinds are on the market. The double box with the nest in the rear is necessary. When a hen has laid an egg and desires to leave the nest, she steps out into the front space and remains there until she is released. With only one section she would be likely to crush her egg by stepping upon it, and thus learn the pernicious habit of egg eating.

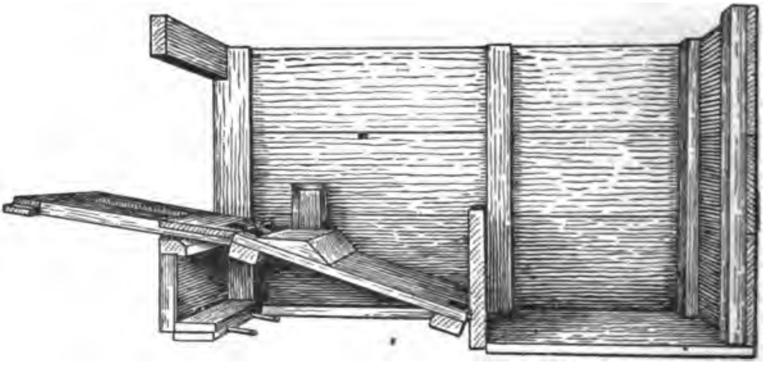

FIG. 9.—Trap nest open. One side removed to show method of operation.

To remove a hen, the nest is pulled part way out, and as it has no cover she is readily caught, the number on her leg band is noted and the proper entry made on the record sheet. After having been taken off a few times the hens do not object to being handled, most of them remaining quiet, apparently expecting to be picked up.

Before commencing the use of trap nests it was thought that some hens might be irritated by the trapping operation and object to the noise incident to it, but such does not seem to be the case. Trap nests have been used at the Maine station for Leghorns, Brahmas, Wyandottes, and Plymouth Rocks.

The amount of time required in caring for the trap nests can only be estimated, since the attendant's time is divided with other duties. The time varies from one day to another and with the number of nests in use. By noting the total time used each day in caring for the nests when the hens were laying most heavily, it has been estimated that one active person devoting his entire time to trap nests could take care of 400 to 500 nests used by 2,000 to 2,500 hens. When commencing the year's work he would need assistance in banding the birds, but after that was done he could care for the nests without assistance until midsummer, when the egg yields would probably be diminished and a part of his time could be spared for other duties.

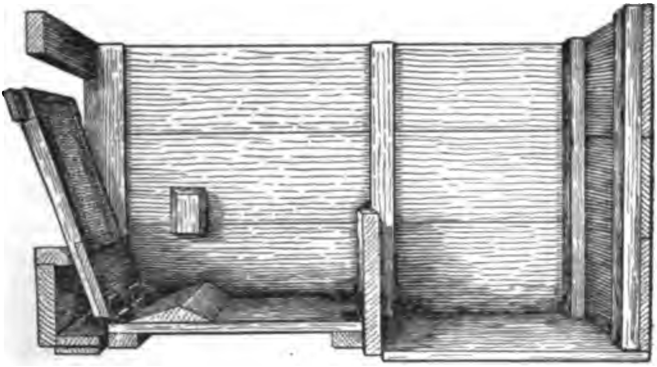

FIG. 10.—Trap nest closed. One side removed to show method of operation.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 358.

A PRIMER OF FORESTRY.

PART II:

PRACTICAL FORESTRY.

BY

GIFFORD PINCHOT,
FORESTER.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., March 15, 1909.

Sir: I have the honor to transmit herewith, for publication as a Farmers' Bulletin, Part II of A Primer of Forestry, bearing the subtitle Practical Forestry. This matter was published in 1905 as Part II of Bulletin 24 of the Forest Service, for which there is a great and continuing demand. To meet this demand Part I has already been issued as Farmers' Bulletin 173, and the issuance of Part II in similar form will make the entire bulletin available for general distribution. The number of illustrations has been considerably reduced.

Respectfully,

Gifford Pinchot, *Forester.*

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Forest management (illustrated) 3
  The service of the forest 3
  The uses of the forest 3
  Four requirements for the best service 6
  The yield of a forest 7
  Silvicultural systems 8
Work in the woods (illustrated) 21
  Conservative lumbering 22
  Planting 29
The weather and the streams (illustrated) 29
  Forests and climate 30
  Effect of forest cover on temperature 32
  Extremes of heat and cold 33
  Moisture in forest air 34
  Evaporation 34
  Rainfall 35
  Fallen rain 36
Forestry abroad and at home 40
  Forestry abroad 40
  Forestry at home 44

A PRIMER OF FORESTRY.

PART II: PRACTICAL FORESTRY.

FOREST MANAGEMENT.

THE SERVICE OF THE FOREST.

Next to the earth itself the forest is the most useful servant of man. Not only does it sustain and regulate the streams, moderate the winds, and beautify the land, but it also supplies wood, the most widely used of all materials. Its uses are numberless, and the demands which are made upon it by mankind are numberless also. It is essential to the well-being of mankind that these demands should be met. They must be met steadily, fully, and at the right time if the forest is to give its best service. The object of practical forestry is precisely to make the forest render its best service to man in such a way as to increase rather than to diminish its usefulness in the future. Forest management and conservative lumbering are other names for practical forestry. Under whatever name it may be known, practical forestry means both the use and the preservation of the forest.

THE USES OF THE FOREST.

A forest, large or small, may render its service in many ways. It may reach its highest usefulness by standing as a safeguard against floods, winds, snow slides, moving sands, or especially against the dearth of water in the streams. A forest used in this way is called a protection forest, and is usually found in the mountains, or on bleak, open plains, or by the sea. Forests which protect the headwaters of streams used for irrigation, and many of the larger wind-breaks of the Western plains, are protection forests. The Adirondack and Catskill woodlands were regarded as protection forests by the people of the State of New York when they forbade, in the constitution of 1895, the felling, destruction, or removal of any trees from the State Forest Preserve.

A farmer living directly on the produce of his land would find his woodlot most useful to him when it supplied the largest amount of wood for his peculiar needs, or the best grazing for his cattle. A railroad holding land which it did not wish to sell would perhaps find it most useful when it produced the greatest number of ties and bridge timbers. In both cases the forest would render its best service by producing the greatest quantity of valuable material. This is the central idea upon which the national forests of France are managed.

The greatest return in money may be the service most desired of the forest. If a farmer wished to sell the product of his woodlot instead of consuming it himself, his woodland would be useful to him just in proportion to its net yield in money. This is true also in the case of any owner of a forest who wishes to dispose of its product, but who can not, or will not, sell the forest itself. State forests, like those in the Adirondacks, often render their best service, in addition to their usefulness as protection forests, by producing the greatest net money return.

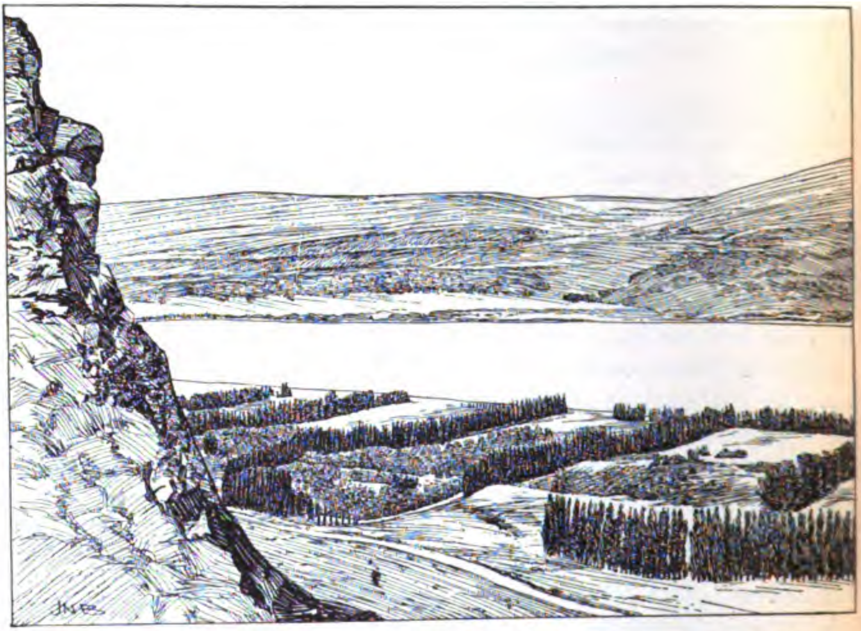

FIG. 1.—Wind-breaks of Lombardy poplar, intended to protect orchard trees against wind and moving sand, near The Dalles, Oregon.

Regarded as an investment of capital, a forest is most useful when it yields the highest rate of interest. A forest whose owner could sell it if he chose, but prefers to hold it as productive capital, is useful in proportion to the interest it yields on the money invested in it. Thus, an acre of sprout land may be worth only $5, while the investment in adjoining land stocked with old trees may be $50 an acre. This is the view which controls the management of state forests in Germany. Lumbermen also regard timber land as an investment, but usually they take no care except for the yield at the moment. They disregard the future yield altogether, and in consequence the forest loses its capital value, or may even be totally destroyed. Well-managed forests, on the other hand, are made to yield their service always without endangering the future yield, and usually to its great advantage. Like the plant of a successful manufacturer, a forest should increase in productiveness and value year by year.

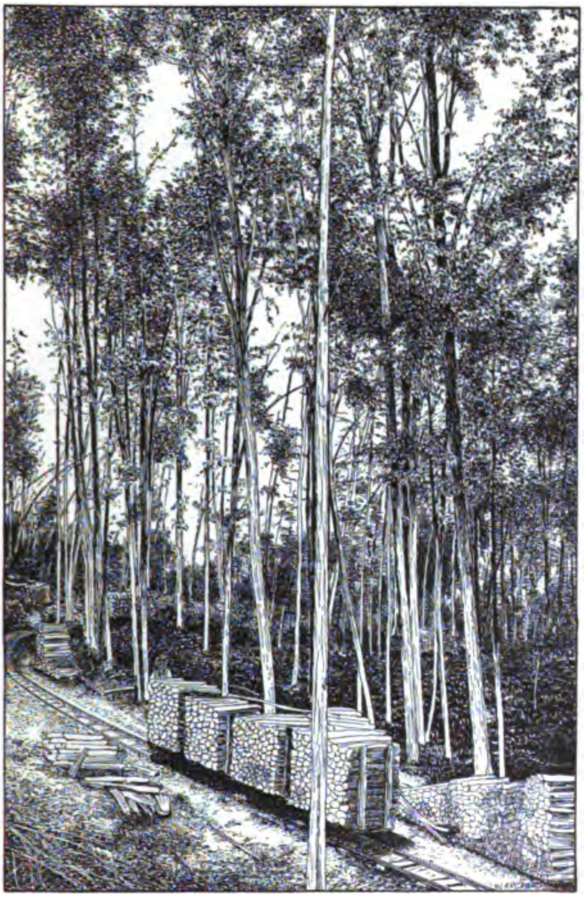

FIG. 2.—Scene in the Sihlwald, the town forest of Zurich, Switzerland, from which its owner desires the greatest net money return.

Under various circumstances, then, a forest may yield its best return in protection, in wood, grass, or other forest products, in money, or in interest on the capital it represents. But whichever of these ways of using the forest may be chosen in any given case, the fundamental idea in forestry is that of perpetuation by wise use—that is, of making the forest yield the best service possible at the present in such a way that its usefulness in the future will not be diminished, but rather increased.

FOUR REQUIREMENTS FOR THE BEST SERVICE.

A forest well managed under the methods of practical forestry will yield a return in one of the ways just mentioned. There are, however, four things a forest must have before it can be in condition to render the best service.

The first of these is protection, especially against fire, overgrazing, and thieves, for without such protection no investment is secure and the most skillful management is of little effect.

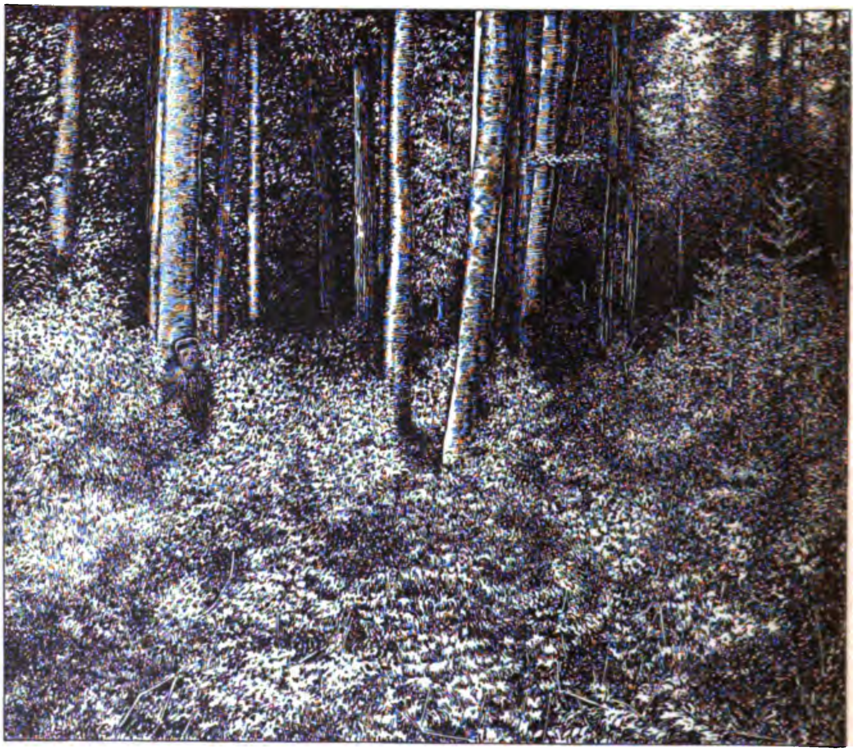

FIG. 3.—Vigorous reproduction along the edge of a forest. Germany.

The second is strong and abundant reproduction. A forest without young growth is like a family without children. It will speedily die out.

The third requirement is a regular supply of trees ripe for the ax. This can be secured only by the right proportion of each of the smaller sizes constantly coming on in the growing forest. Thus, a farmer in need of fuel might be much inconvenienced to find no trees on his woodlot big enough for cordwood, and it would not help him to know that twenty years later he would have an oversupply. In the same way a larger forest may yield only a very irregular and unsatisfactory product if at one time there are too many ripe trees and at another too few. For example, if 100 acres become fit to cut this year, and 200 next year, and after that none at all until 500 acres become ripe fifteen years later, it is easy to see that the yield would come at very irregular and perhaps very inconvenient times. But a forest of 10,000 acres, composed of 100 even-aged groups of trees of every age from 1 to 100 years, each group 100 acres in extent, would plainly be able to furnish every year 100 acres of 100-year-old trees ready for the ax. In such a forest the right proportion of young trees would always be coming on.

The fourth requirement is growing space enough for every tree, so that the forest as a whole may not only produce wood as fast as possible, but the most valuable sort of wood as well. If the trees stand too far apart, their trunks will be short and thickly covered with branches, the lumber cut from them will be full of knots, and its value will be small. If, on the other hand, the trees stand too closely together, although their trunks will be tall and clear of branches, they will be small in diameter, and for that reason low in value. With the right amount of growing space, trees grow both tall and of good diameter, and their trunks supply lumber of higher price because it is wide and clear.

THE YIELD OF A FOREST.

One of the central ideas of forestry is that the amount of wood taken from any healthy forest and the amount grown by it should be as nearly equal as possible. If more grows than is cut, then the forest will be filled with overmature, decaying trees; but if more wood is cut than is grown, then the supply of ripe trees will be exhausted, and the value of the forest will decline. To make the cut equal to the growth does not mean that the volume of wood grown each year on every acre should be cut from that acre, but that the total growth of all the acres, for one or for a number of years, should be cut from the forest in the corresponding period. Thus, if the growth or increase is 100 cords a year, that amount might be harvested yearly by cutting every tree on a small area, by cutting fewer trees per acre on a larger area, by distributing the cut every year over the whole surface of the forest, or by cutting 1,000 cords in any one of these ways once in ten years.

There are many different methods of finding what is the annual increase of wood in a forest. One of the simplest is to count the number of trees upon an acre and select an average tree, then to cut it down, measure its cubic contents, and find its age by counting the annual rings. That done, the yearly increase of the average tree may be found by dividing its cubic contents by the years of its age.

Finally, since we have found the yearly increase per tree and the number of trees per acre, it is easy to find the average yearly increase per acre. It is unfortunate that this simple and easy process is not always reliable, because it is hard to find either an average acre or an average tree.

The yield of a forest is the amount of wood that is taken from it in a given time. When a forest is put under conservative management, one of the most important steps is to decide how much timber can safely be taken from it; in other words, to determine the yield. There are three principal ways of doing so.

The first, and the least used, is to fix the yield at a certain number of mature trees. By this plan the yield of a certain forest might be 100 pines, 260 spruces, and 180 hemlocks, each of a given diameter, every year.

The second way is to fix the yield at a certain amount or volume of wood. Thus, the yield of a large forest might be fixed at 25,000,000 feet board measure every ten years, and that of another smaller one at 750 cords every year.

The third way is to settle upon a certain number of acres to be cut over yearly or once in a given number of years. By this method the yield of a forest of 600 acres might be fixed at 6 acres of mature timber a year, and that of another at 300 acres every twenty-five years. The time between two successive cuttings on the same area must be long enough to allow the young trees left standing to mature. That time is found by studying the rate of growth in diameter.

This method of determining the yield by area is much the most practicable of the three for the forests of the United States, and in general it is the simplest and most widely useful of all, because it does away with the difficult task of determining the yearly increase in wood.

The objects in handling forests are so various that sometimes no single one of these methods is satisfactory, and then combinations of them are of great use. Thus, by combining the method by volume and the method by area the annual yield of a forest might be established at 250 board feet per acre. This yield might be cut from the forest every year, or it might be allowed to accumulate for twenty years, and then 5,000 board feet per acre might be cut.

SILVICULTURAL SYSTEMS.

After the yield has been found it must be cut not only without injury to the future value of the forest, but in such a way as to increase its safety and usefulness. To this end certain ways of handling forests, called silvicultural systems, have grown up. They are based on the nature of the forest itself, and are chiefly imitations of what men have seen happen in the forest without their help.

From the point of view of forest management, one of the principal differences between trees is whether they spring directly from seed or are produced as sprouts from stumps or roots already in the ground. A forest composed of seedling trees is called a seed forest, or more commonly but less suitably, a seedling or high forest. One composed of sprouts is spoken of as a sprout or coppice forest, or, more often, simply as coppice, or as sprout land. Seed forests are usually composed of coniferous trees, which rarely sprout, or of broadleaf trees allowed to reach large size. Sprout forests are common wherever broadleaf trees are cut while they are still young, for the sprouting power usually diminishes with age. Sprouts never reach so great a height and diameter as seedling trees, although in youth they grow much faster; and they are apt to be unsound, because the old stumps decay and infect the sprouts which spring from them.

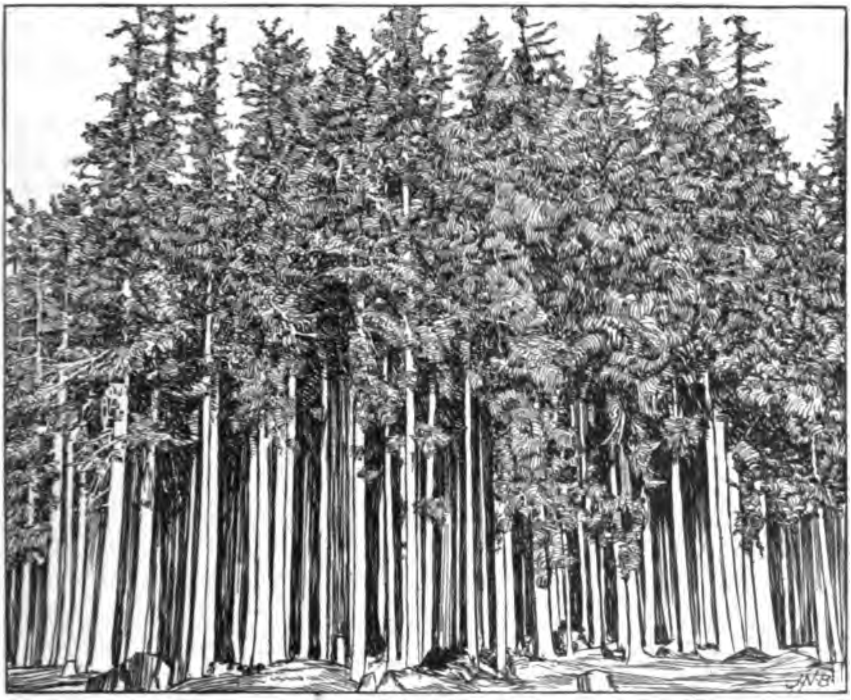

FIG. 4.—Seed forest of fir in Washington.

Simple coppice.—It oftens happens, as in Pennsylvania or New Jersey, that a fire sweeps over the second-growth hardwood lands and kills all the young trees down to the ground; but the roots remain alive, and from them spring young sprouts about the bases of the burned trunks. After several years a second fire may follow and kill back the sprouts again, and other fires may continue at intervals to burn over the land, each followed by a new crop of sprouts. When a farmer does with the ax what is often done by fire he is using the system of simple coppice. Let us suppose a farmer has a woodlot covered principally with chestnut sprouts which he wants to manage for the steady production of railroad ties. He knows that chestnut sprouts are usually large enough for ties at the age of 35 years. In order to insure a steady yield of trees fit for ties, he divides the whole woodlot into thirty-five parts of equal productive capacity, and cuts one part clean every year. All the new sprouts that spring up on the part cut in any year are of the same age. At the end of thirty-five years, when the whole woodlot has been cut over, the thirty-five parts form a series of even-aged groups of sprouts from 1 to 35 years old. Every year the sprouts on one part reach the age of 35 years and are ready for cutting.

Simple coppice is a very useful silvicultural system, and the easiest of all to apply. The chief requirements for its success are good reproduction from the stumps, proper thinning (where thinning can be made to pay), and enough young seedlings among the sprouts to replace exhausted stumps with vigorous young ones. Stumps from which the sprouts have been cut many times finally grow weak and lose their power of sprouting.

In cutting sprouts it is important not to loosen the bark on the stumps, for that impairs their sprouting power, and to make the cut as near the ground as possible. Stumps cut level with the surface sprout best of all. In simple coppice, well handled, the reproduction takes place of itself without the need of further attention from the forester.

Many thousands of acres of American woodland, especially in New England, New York, Pennsylvania, and New Jersey, and in other places where chestnut is the principal tree, are treated under a rough system of simple coppice.

Stored coppice.—Among the trees which will produce only fuel, fence posts, or railroad ties there often stand in a woodlot others which would yield much larger returns if they were allowed to reach a greater age and size than the trees about them. If there were some white oaks scattered through the chestnut coppice just described, it might be well to let them grow large enough for the production of high-priced material like quartered oak lumber. In that case it would be necessary at the time of cutting the sprouts to select and leave standing a certain number of white oaks on every acre. As many of them as survived the increased exposure to wind and sun following the sudden removal of their neighbors would remain as standards over the young sprouts. The white oak standards thus chosen would remain uncut during two, three, four, or sometimes even five successive crops of sprouts, and would form stout trunks with little taper, clear of branches almost to the full height reached by the sprouts.

This is the silvicultural system called stored coppice, or sometimes coppice under standards. The successful management of a forest under it depends largely upon the choice of the standards. They should be seedlings, for seedlings make the best trees, or the most vigorous and healthy sprouts if seedlings can not be found, and they should be distributed as regularly as possible over the ground. The standards should be numerous enough at first to allow for

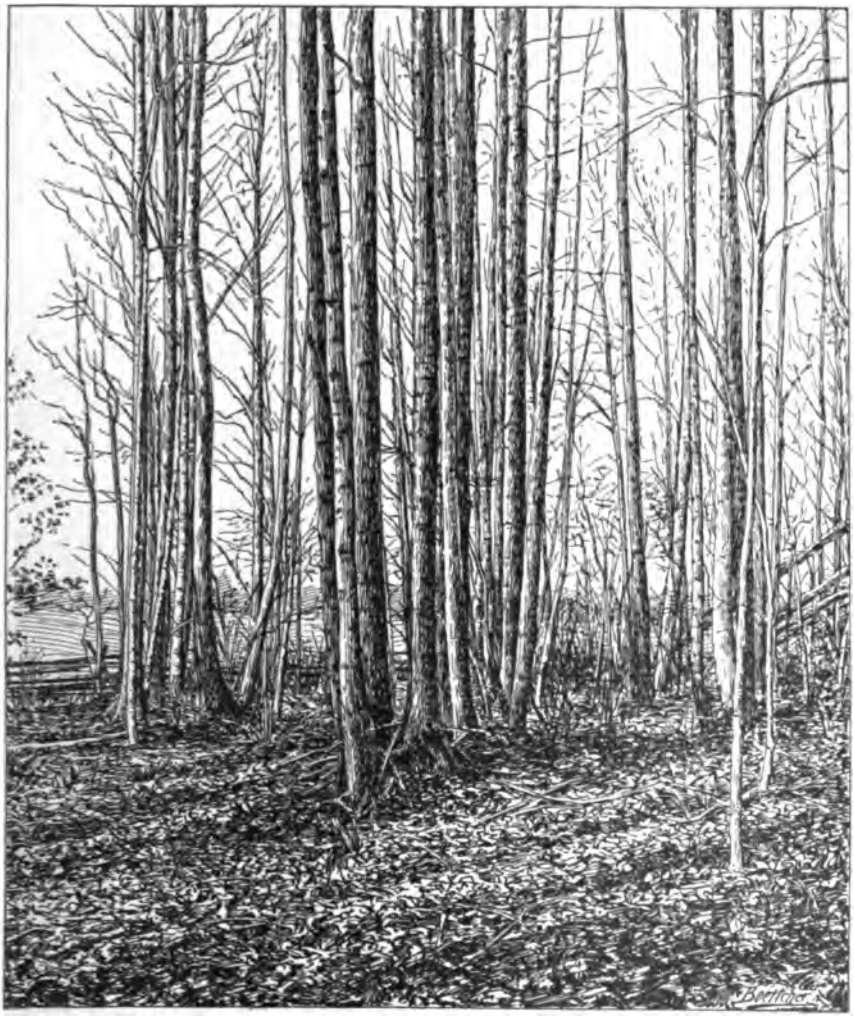

FIG. 5.—Yellow poplar sprout forest in Maryland.

heavy loss from wind and shock when the sprouts are cut away, but they should never be allowed to suppress the lower story of growth.

Stored coppice is a very useful system where the principal demand is for small material, like fuel, ties, and fencing, but where some large timber also is required. It was developed chiefly by the French, who use it with admirable results.

Seed or high forest.—By far the most useful and important forests are, as a rule, those which spring directly from seed, such as the pine forests of the Southern States and the great hardwood forests of the Mississippi Valley. Such forests are called seed forests. The seed-forest systems are of many kinds, some of which are peculiarly adapted for the management of certain forests in the United States. Just as the sprout-forest systems are chiefly useful to produce fuel, posts, ties, and trees of small size, so the seed-forest systems are producers of sawlogs and large timbers.

Regular seed forest.—When a tract of woodland is destroyed by fire in one of the Rocky Mountain States, it often happens that the seeds of the lodgepole pine are scattered over it by the wind in prodigious numbers. The seeds germinate abundantly, seedlings spring up, and in a very few years a young even-aged forest of lodgepole pine covers the ground. As it grows older fires destroy patches of it here and there, and in time every patch is covered again with a younger generation of even age. After many years the forest which sprang up after the first fire has become broken into a number of even-aged patches without uniformity in size or regular gradations in age.

Now let us suppose that this land was taken in hand by the Government when the lodgepole pine first came in, and that the lodgepole reaches its maturity at 80 years. If the government forest officers had divided such a forest into eighty parts, and then had cut the timber from one part each year, after a time they would have had eighty divisions, each covered with even-aged forest, but differing in age among themselves from 1 to 80 years. Every year one part would reach the age of 80 years and would be cut, and evidently the other seventy-nine parts would always be stocked with trees from 1 to 79 years old.

When the trees on one of the eighty divisions just mentioned become ripe for the ax, provision must be made for a new crop. This would be a very simple matter if the forest on that division could be reproduced naturally in one year, but that is practically impossible. Such rapid reproduction can be got only by planting, which is chiefly useful in the United States for making new forests and restoring injured forests, not for renewing old ones. Reproduction from the seed of the old trees is the only kind we need consider here. In order to bring it about a few ripe trees are first cut down, to prepare a seedbed by giving light to the soil, and to fit the seed trees to bear more abundantly by giving the crowns more room. Then, when a good crop of seed is likely to appear, a few more trees are removed to give the future seedlings light enough for healthy growth, but not enough to expose them to danger from frost, drought, or the choking of grass and weeds, for young trees just starting in life are very sensitive and easily destroyed. Finally, as the young trees grow taller and stronger, what remains of the old crop is gradually cut away. When it is all gone, usually from ten to twenty years have passed since the reproduction cuttings were begun.

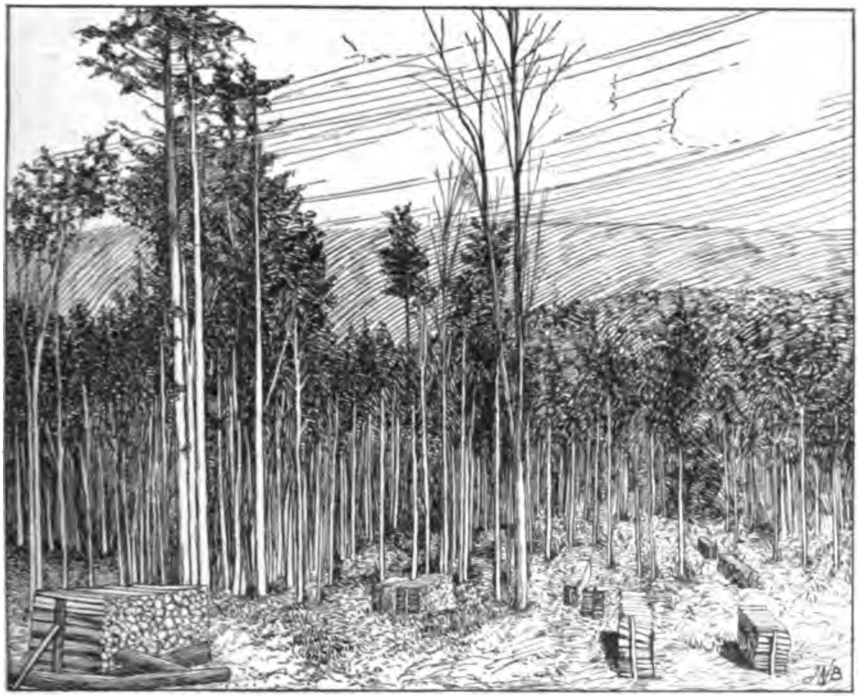

FIG. 6.—Mixed forest in process of gradual reproduction. Sihlwald, Switzerland.

This is the system of regular seed forest. It is difficult to apply, and unsafe except in experienced hands. It has often been necessary to plant large areas at great expense because reproduction cuttings in regular seed forest have failed. The transportation of the timber is frequently expensive,, because it must be spread over a number of years. On the other hand, when it is well applied this system produces the highest type of forest, full of tall straight trunks clear of branches, and consequently yields a high grade of timber and a large return in money. .

Two-storied seed forest.—After a forest fire in Maine it frequently happens that the first tree to cover the ground is the popple, or quaking aspen. It is a slender, short-lived tree, intolerant of shade, with a light crown. After the popple has grown for some years, spruce seedlings spring up under the friendly cover, and rapidly follow the popple in height. There grows up in this way a forest composed of an upper and a lower story of growth, in which, as so often happens, the lower story is of more importance.

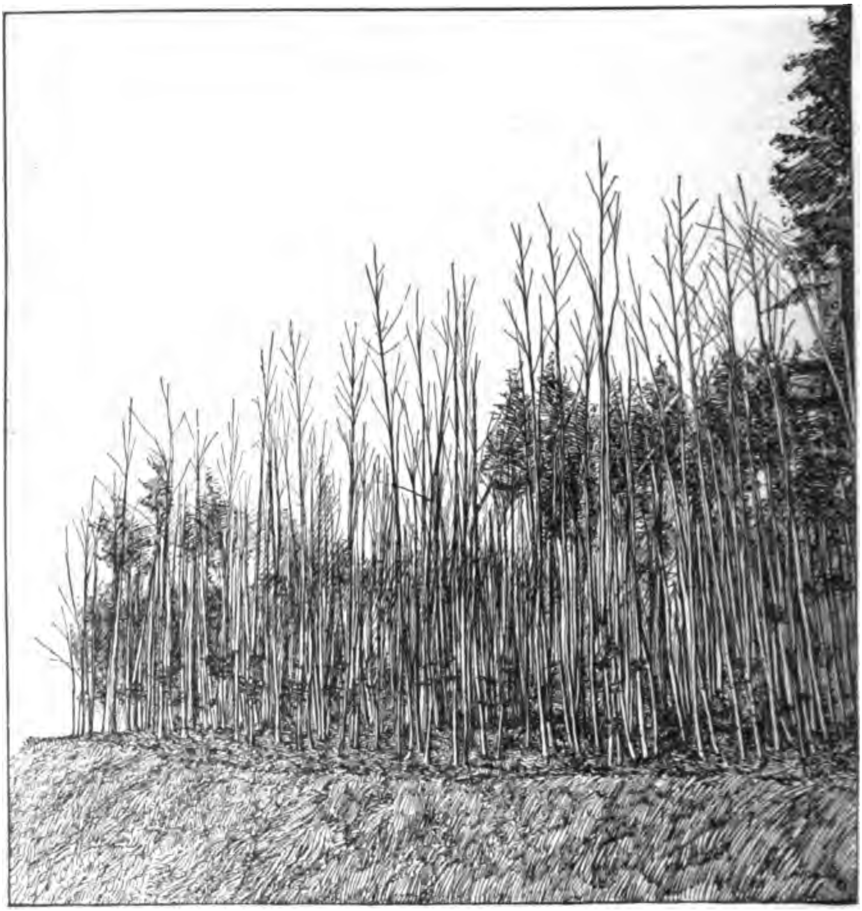

FIG. 7.—Reproduction obtained by process shown in figure 6. Sihlwald, Switzerland.

The system of two-storied seed forest is useful when a tolerant tree like the spruce is to be grown under the shade of an intolerant tree like the aspen. In countries where forestry is well developed it is usual to plant young trees of tolerant species under older intolerant trees, to make a cover for the soil and to prevent the growth of grass and weeds. Forests which closely resemble two-storied seed forests are common in the United States, but usually as the result of fire or careless cutting. Such are, for example, the forests of pine over oak in the southeastern United States, and of birch, beech, and maple under white pine in Michigan, Wisconsin, and Minnesota. It often happens, as in the case of the spruce and aspen, that both stories can not live on in good health together, and that the upper one must die or be cut away if the lower is to prosper.

Selection forest.—When a stand of aspen dies away from a young crop of spruce, the ground is no longer completely shaded, and there is light and room for other kinds of trees to come in. Thus, birch and maple seeds may be blown in by the wind and beechnuts carried and planted by squirrels, and eventually the pure stand of spruce is changed into a mixed forest of various ages. As the trees grow older, some of the spruce may be destroyed by beetles or thrown by the wind, and some of the broadleaf trees may die from fungous disease. Into the openings made by the death of older members of the forest fall the seeds from which younger members spring. So little by little the forest loses its even-aged character and there comes into existence what is called a natural or selection forest, in which trees of all ages are everywhere closely mixed together. Most virgin forests are selection forests.

The silvicultural system called pure selection is applied to forests of this kind. It is used chiefly for protection forests in places where it is desirable to keep the cover always unbroken; elsewhere it is out of place. Under this system the annual increase of the forest must be found before the yield can be determined. (See p. 7.) Then the fully mature trees are cut in every part of the forest every year. The cost of logging is high, for where single trees are taken here and there, roads or other means of transport must be very numerous and costly in proportion to the amount of the cut.

Localized selection.—Logging under the system just mentioned is so expensive as to prevent its application in the United States, except for woods like cherry and black walnut, which have a special and unusual value. But if, instead of taking the yield from every part of a selection forest, a comparatively small area is cut over each year, the cost of logging may be very greatly reduced. Such a method is admirably adapted to certain forest regions in the United States, as, for example, to the Adirondack Mountains of New York, where the forest is composed equally of coniferous and broadleaf trees. The conifers are the more valuable, and among them the principal lumber tree is the spruce.

The Forest Service has found by many careful measurements that if all spruce trees 12 inches and over in diameter are cut from certain portions of the Adirondack forest, the younger spruce will grow up and replace the original stand of timber in about twenty years. But this will not happen unless the rules for cutting are faithfully observed, nor will it happen more than once unless enough old trees are left standing for seed. Such a forest may then be divided into twenty parts, and the merchantable timber about 12 inches in diameter may safely be cut from one division every year. By the time the last of the twenty divisions has been cut over, the first will have upon it a stand of mature spruce equal in quantity to that of twenty years before. The yield of the whole forest in spruce for a single year may be cut each year from one-twentieth of the whole area. If all the divisions were cut over five times in the life of a mature tree, then one-fifth of the standing timber would be taken from each division at each cutting. Thus, if it took one hundred years for a tree to become ripe for the ax, the cutting (at intervals of twenty years) would return five times during the life of the tree, at its twentieth, fortieth, sixtieth, eightieth, and one hundredth years.

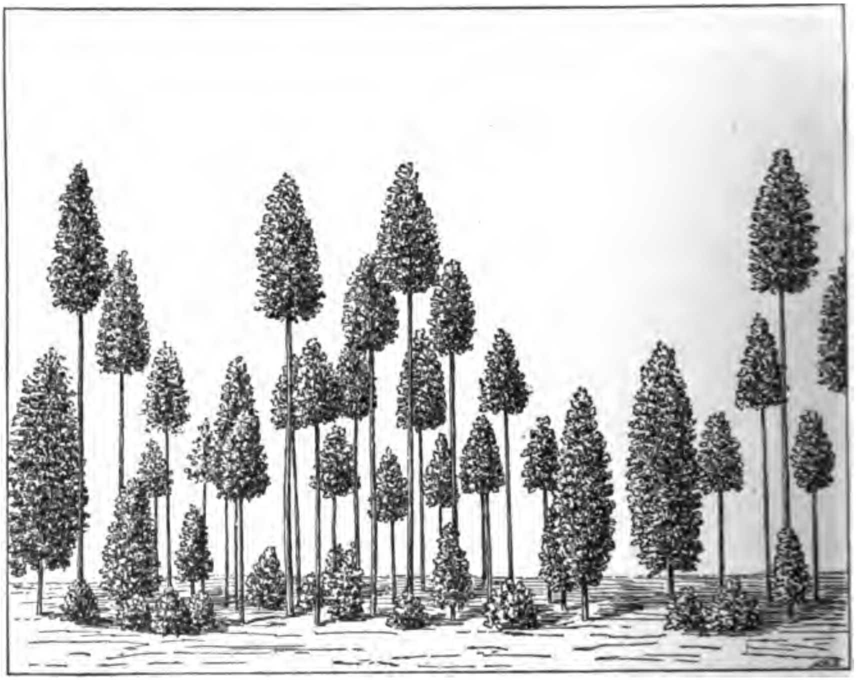

FIG. 8.—Mimic pure selection forest, showing mixture of ages.

This is the system of localized selection. It is simple and easy to apply, and even if mistakes occur they are not apt to have dangerous consequences. It is very elastic and has many forms, and it is well adapted to many different kinds of forest. Logging is cheap, because the area cut over in any one year is small, and the reproduction is provided for by natural seeding in the openings of the forest

The group system.—It often happens that all the trees of a small group in the forest are killed by fire or insects at about the same time. In the opening thus made the ground is quickly covered with young growth, which extends back under the old trees as far as the light will permit. The seedlings are usually tallest, strongest, and most numerous directly under the middle of the opening, and gradually decrease at the sides. If the wind should throw some trees at the edges of such an opening the young growth would gradually extend, and if the same thing should continue to happen in the end all the old trees would have disappeared and their places would have been taken by young growth. The group system is an imitation of this process.

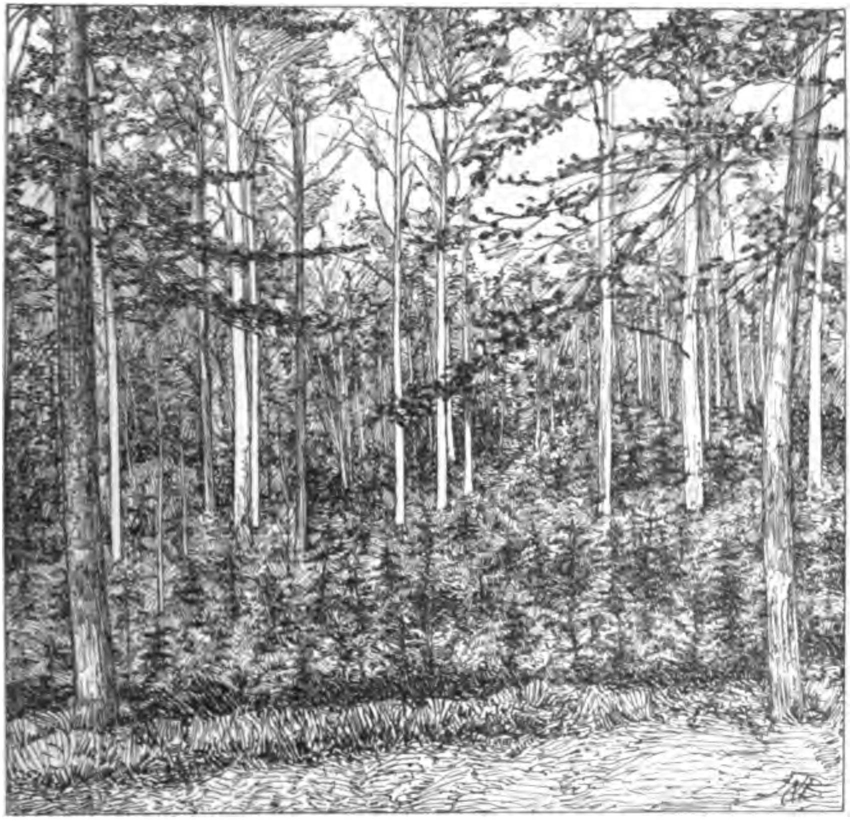

FIG. 9.—Group of spruce under beech. Germany.

Under the group system openings are made here and there in the forest by cutting away ripe trees. As the reproduction proceeds, the old trees about the openings are gradually cut away, and the groups of young growth, spreading from the original openings like drops of oil on water, finally meet.

This is one of the simplest and most useful of all the systems, and when the openings are made small at first no other is so safe. It is especially adapted to small pieces of forest, such as woodlots, because it is simple, and because it assures the safety of the forest even with very little skill or care on the part of the owner.

The strip system.—In nearly every wooded region of the United States a tornado occasionally destroys the trees in a long and narrow belt through the forest. Fire often follows and clears the strip by burning up the fallen timber. Seeds then fall in the opening, carried from the trees on either side, the seeds germinate and grow, and the reproduction of the forest takes place.

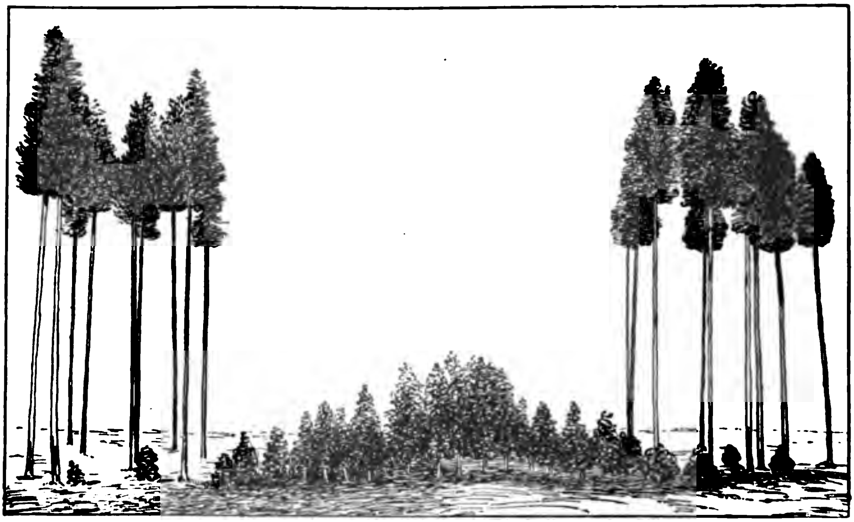

FIG. 10.—Mimic forest, showing distribution of young growth under the group system.

When the ax takes the place of the tornado and the timber is logged instead of being burned, the strip system is applied. Reproduction follows from trees on either side, as before.. The strip system consists in cutting long narrow openings in the mature timber instead of the circular openings of the group system, to which it is similar in many ways. It is simple and effective when natural reproduction is good, and well suited for extensive operations in places where careful work is impossible. The strips are usually not over 100 yards in width. Where the soil is dry, they are run east and west to protect the young growth against the sun, and are comparatively narrow. If there is serious danger of windfall, they lie at right angles to the direction of the wind.

These are the most important of the silvicultural systems. They have many modifications, and indeed each forest may require a special form of its own, which must be devised or adapted for it by the forester. But whatever the form, the object is always to use the forest and provide for its future at the same time.

Improvement cuttings.—Very many forests in the United States, and especially many woodlots, are in poor condition and unfit for the immediate application of any silvicultural system. They need to be put in order, and for that purpose improvement cuttings are usually required. In the end these cuttings should remove all trees which the forest is better without, but they should be made gradually, so as not to open the cover too much and expose the soil to the wind and the sun. In general, it is unwise to cut more than 25 per cent of the poles and older trees in a dense mature forest, or to cut oftener on the same ground than once in five years. Improvement cuttings of course should never fall on trees which are to form the future crop, but they should remove spreading older trees over promising young growth; poor trees which are crowding more valuable ones; unsound trees whose places will be taken by others of greater value, or which are themselves becoming less valuable from year to year; and seed

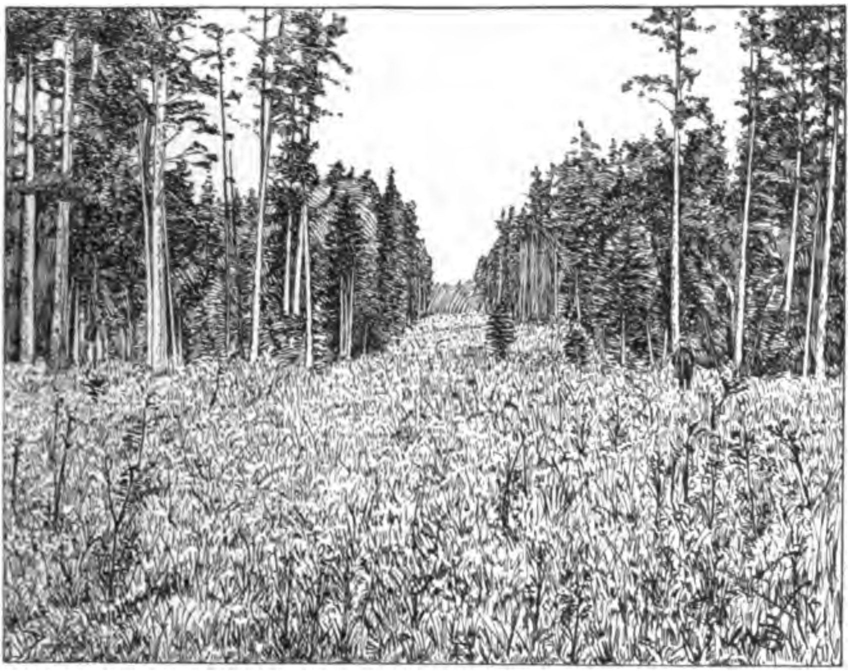

FIG. 11.—Spruce managed under the strip system. Southern Russia.

trees of undesirable species likely to reproduce themselves, if reproduction of more useful kind is well assured. The great majority of woodlots need such cutting, and when they do, whatever wood is taken from them should be cut in this way.

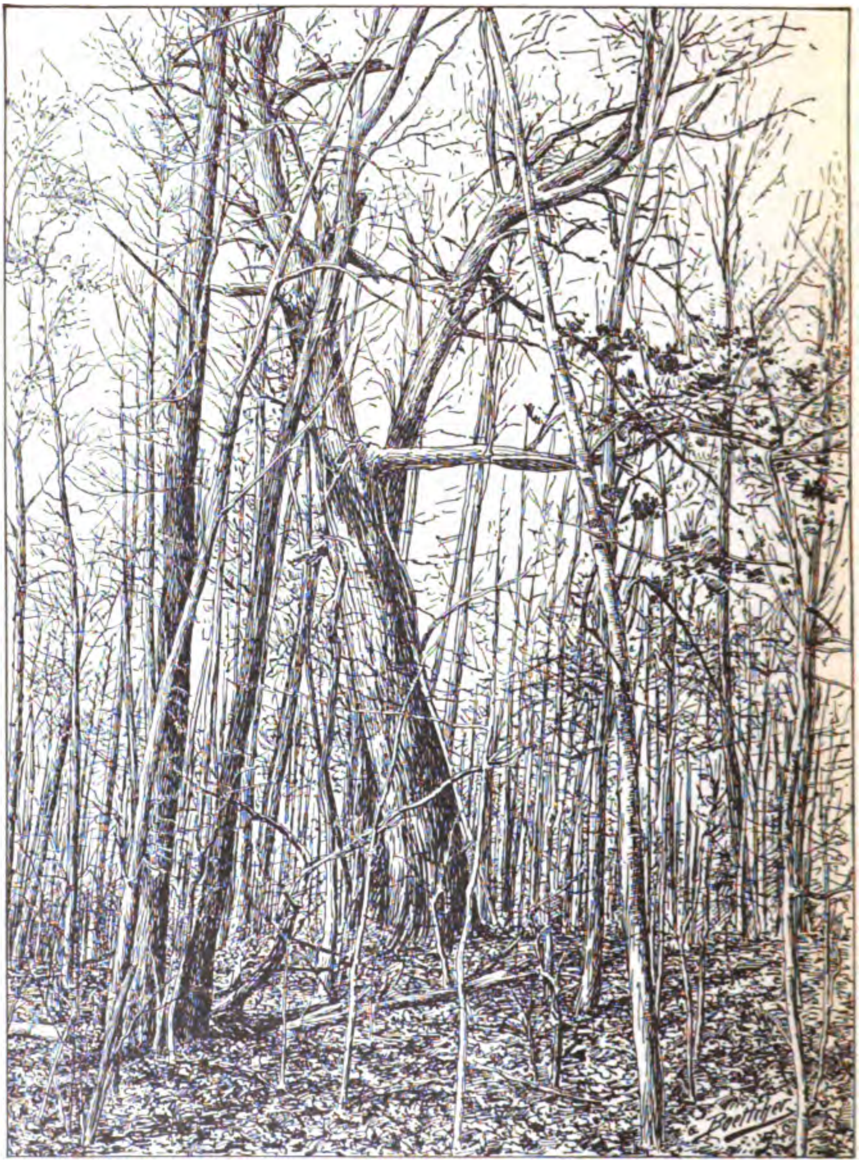

FIG. 12.—Mixed forest in need of an improvement cutting. The crooked old chestnut, in the center, in particular should be removed.

WORK IN THE WOODS.

The products of the forest are among the things which civilized men can not do without. Wood is needed for building, for fuel, for paper pulp, and for unnumbered other uses, and trees must be cut down to supply it. It would be both useless and mistaken to try to stop the cutting of timber, for it could not cease without great injury, not to the lumbermen only, but to all the people of the nation. The question is not of saving the trees, for every tree must inevitably die, but of saving the forest by conservative ways of cutting the trees. If the forest is to be preserved, the timber crop now ripe must be gathered in such a way as to make sure of other crops hereafter.

In general, it is true that the present methods of lumbering are unnecessarily destructive and wasteful. This is not because lumbermen are more greedy of gain or less careful of public interests than other business men, for they are not. It happens partly because in this country, compared with France and Germany and other densely populated regions, there is so much timber in proportion to the population that it does not pay the lumberman to take anything more than the better parts of the trees he fells. The lumberman can not do his work unless he does it at a profit, and he must do it, for lumber is indispensable. Consequently, although much of the waste in lumbering is not only unnecessary but actually costly to the lumberman, for the present it is impossible to avoid waste altogether. It will be easier to do so when the methods and advantages of conservative lumbering, which is forestry, are better known to the American lumbermen, and are therefore in more general use. Although rough conservative methods have often been practiced in the past, the success of the lumbermen who made the trial was generally but partial, because their knowledge of the forest was partial also. They were often deceived by underestimates of the capacity for tree growth of the lands they were handling, because accurate measurements were wanting, and they seldom made full use of the reproductive power of the forest. More recent attempts, based on better knowledge, have been successful in almost every case.

Lumbermen in America are second to none in skill and ingenuity, in the perfection of their tools, and in the effectiveness of the methods they have devised. The nations of Europe, although they have given far more attention to forestry than we, are very much behind the United States in these respects. So it is not surprising that Americans have been slow to change their methods, especially when methods and lumbermen alike have often been attacked as wrongly and intemperately as the foreign methods have been praised and recommended. German methods would be as much out of place in America as American methods in Germany. What American foresters should do and are doing is to combine the general principles of forestry, which are true all the world over, with American methods of lumbering. The product will be a system of forestry especially adapted to the United States. The foundations of such a system are already laid.

CONSERVATIVE LUMBERING.

Something was said in the last chapter about the systematic methods of conservative lumbering. With the gradual understanding and application of these methods by American lumbermen, already well begun, and with the work in the woods rightly carried out, there is but one reason why the great majority of the forests now standing in the United States should not in the end be lumbered steadily and systematically, or why they should fail to yield a steadily increasing return. That reason is the rapid destruction of the forests themselves. There is grave danger that the best of our forests will all be gone before their protection and perpetuation by wise use can be begun. The spread of a working knowledge of practical forestry is likely to be too slow.

Conservative lumbering and ordinary lumbering. — Conservative lumbering is distinguished from ordinary lumbering in three ways:

First. The forest is treated as a working capital whose purpose is to produce successive crops.

Second. With that purpose in view, a working plan is prepared and followed in harvesting the forest crop.

Third. The work in the woods is carried on in such a way as to leave the standing trees and the young growth as nearly unharmed by the lumbering as possible.

A forest working plan is intended to give all the information needed to decide upon and carry out the best business policy in handling and perpetuating a forest. It gives this information in the form of a written statement, which covers some or all of the following topics: It shows the present stand and condition of the forest, and gives rules for the selection and marking of trees to be cut, for making the reproduction sure, and for the protection of young and old standing trees during the logging. The working plan also predicts the future yield of the forest, basing its prediction on careful measurements which show how many standing trees of different diameters will be left per acre after the first cutting, and how fast these young trees grow. Finally, it estimates the future return in money, taking into account the taxes, interest, and other expenses on one side and the future crop on the other. In order to make this estimate entirely safe it is usually based on the present price of stumpage, although its future value will certainly be much higher.

Felling the trees.—The difference between the practical work under ordinary lumbering and under conservative lumbering is chiefly in the selection of the trees to cut, in felling them, and in the first part of their journey from the stump to the mill. Under a working plan the trees to cut are chosen in such a way that when they are gone the forest will suffer but little from their absence, because their places will be taken by others as quickly as possible. Usually the trees selected are first stamped with a marking hatchet to prevent mistakes, and then the next step is to cut them down.

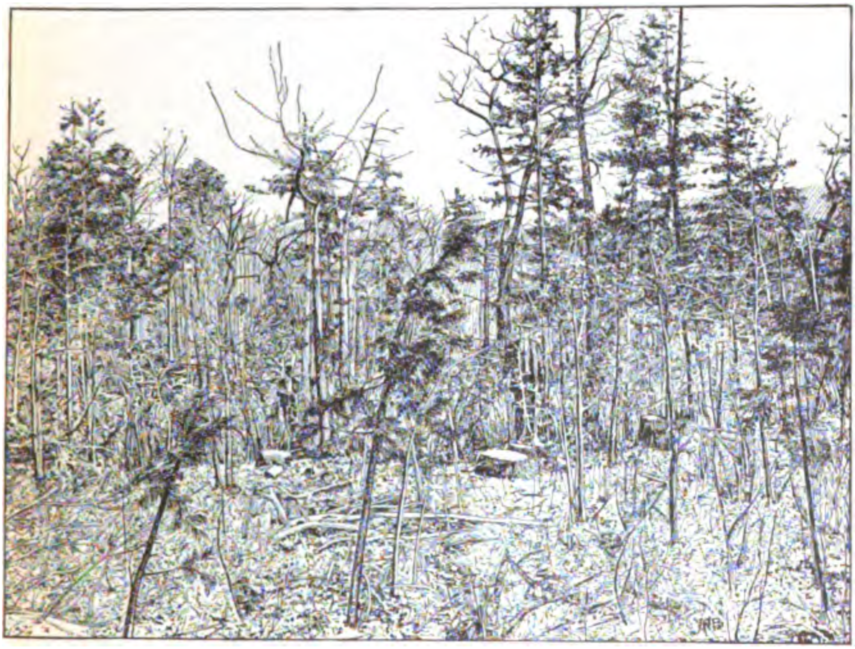

FIG. 13.—Low stumps in logging.

The amount of harm done to the forest by the cutting depends considerably upon the season of the year when the work in the woods is carried on. Less damage results to the young growth and the trees left standing if the lumbering is done after the growing season is over than if it goes on in the spring and summer while the bark is loose and the leaves and twigs are tender.

A tree may be felled either with the ax or with the saw. In either case the first thing to consider is the height above the ground at which the cut is to be made. High stumps needlessly waste the best timber in a sound tree. Low stumps are slightly more difficult to cut, and therefore a little more expensive, but the additional cost is more than balanced by the gain.

The measurements made by the Forest Service have shown that the loss from cutting high stumps on a tract of 100,000 acres in the Adirondacks, yielding on an average 15 standards per acre, would be 30,000 standards, or at a stumpage value of 50 cents per standard would be $15,000.

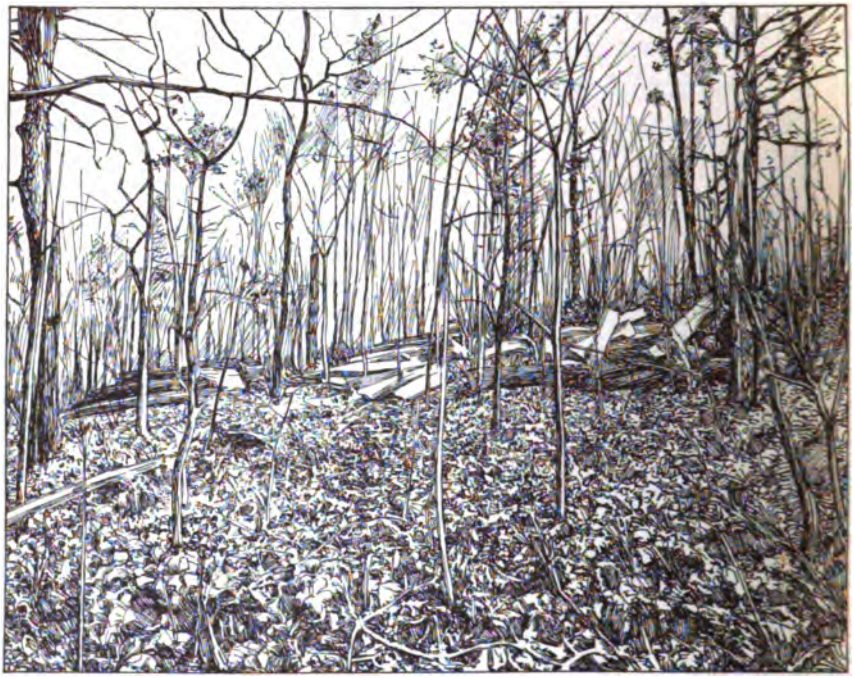

FIG. 14.—Protection to young growth in logging. Biltmore, N. C.

The second thing to consider in felling a tree is how to get it down without breaking or splitting the trunk. On rocky, uneven ground this is often a hard thing to do, but unless it can be accomplished the tree would, as a rule, better be left untouched.

Most important of all for the perpetuation of the forest, each tree must be thrown where it will not unnecessarily injure other trees or crush in its fall the young seedlings on which the future of the forest depends. It happens very commonly in ordinary lumbering that vigorous, sound young trees are split and ruined in great numbers by old trees falling upon them, when it would be perfectly easy and almost or quite as convenient to throw the latter where they would do little or no harm.

Finally, it must cost as little as possible to fell each tree, for to be successful conservative lumbering must pay.

Swamping and sawing.—When the trees are down their lower branches are chopped off and the trunks are sawed into logs. In falling, a tree is very apt to bend and hold down beneath its trunk and branches many younger trees, which will spring up straight again if they are quickly released, but which otherwise will be killed or permanently hurt. Therefore it is very important to work up both the trunk and the top of each tree as soon as it is cut down, and so prevent it from destroying the young trees which should take its place. Except when they are to be burned, even the branches of tops which can not be used should ordinarily be cut away enough to let the tops sink close to the ground, where they will rot as speedily as possible. Dry crowns propped clear of the ground by their branches rot slowly, burn fiercely, and are very dangerous in case of fire.

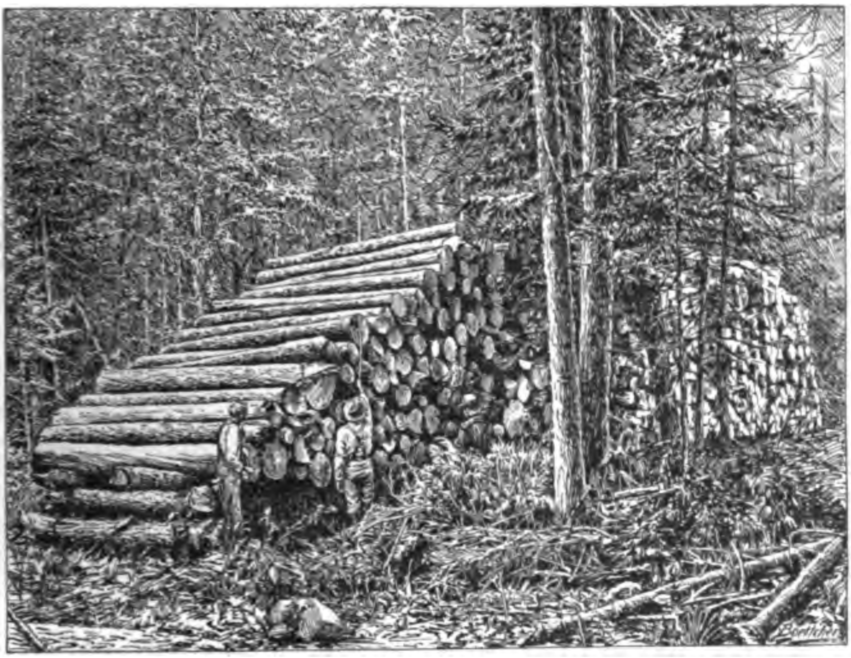

FIG. 15.—Spruce rollway. Adirondack Mountains, New York.

Skidding.—When the trunks have been sawed into logs the latter are dragged away by horses, mules, or oxen, or in some cases by a long wire rope which is wound on the drum of a donkey engine. This is called "skidding the logs." In this way they are collected in piles called "rollways," or assembled in "yards," or otherwise made ready for the next step in their progress to the mill.

Care is needed in skidding not to rub or tear the bark from valuable standing trees or to break the young growth down, for much harm is quickly done in this way. Promising young trees are often cut because it is easier to use them for corduroy or skids or for other purposes in the logging than to take others less straight or less conveniently at hand, or because they are somewhat in the way, or even from habit, when it would really be easier to let them alone. A very little care in preserving young growth makes an astonishing difference in the future value of a forest.

Transportation.—After the skidding the logs may be transported to the sawmill in many different ways. Sometimes they are loaded on sleds and drawn over carefully made ice roads to a logging railroad or to the bank of a stream. When the stream is not swift or deep enough to carry the logs of itself, splash dams are built, in which great quantities of water are held back for a time. When such a dam is opened the water is set free and great numbers of logs may be driven far down the stream by the sudden flood. In larger streams the logs are sometimes made into rafts, or they may be driven singly down the river. The log drivers who do this work learn to balance themselves on the floating, rolling logs, and walk on them almost as easily as on the solid ground. Sometimes locomotives drag the logs behind them over the ties, or they are hauled on cars which run over

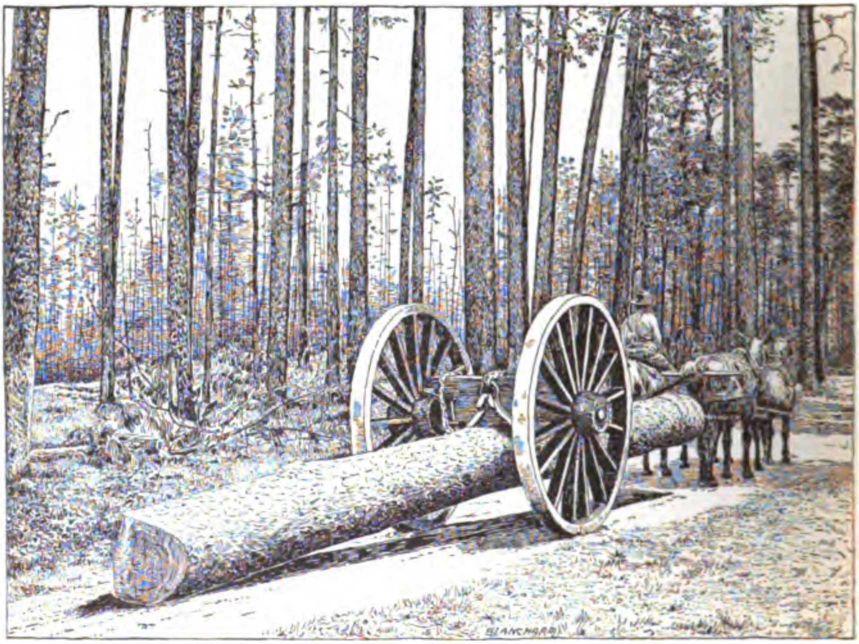

FIG. 16.—Hauling loblolly pine. South Carolina.

poles cut in the woods instead of over metal rails; often they are rolled into slides built of other logs, and either move downhill by their own weight or are dragged along by horses, cattle, or steam. In southern swamps the logs are sometimes swung up by a wire rope suspended from the trees, and so are loaded on the great flatboat which carries them to the mill.

At the mills.—At the mills the logs are cut into lumber by various kinds of saws. Of these the circular saw is still very widely used, although the wide bite or kerf which it cuts in the log makes it very wasteful of timber. A large circular saw makes a kerf a quarter of an inch wide, so that in cutting four one-inch boards enough wood to make a fifth board is ripped into sawdust. Band saws are far less wasteful, for they are thinner and make a narrower kerf. Hence they are taking the place of the circular saws, although they do not work so rapidly. Many mills, in addition to their band saws or circulars, use gang saws, which cut out several boards at the same time.

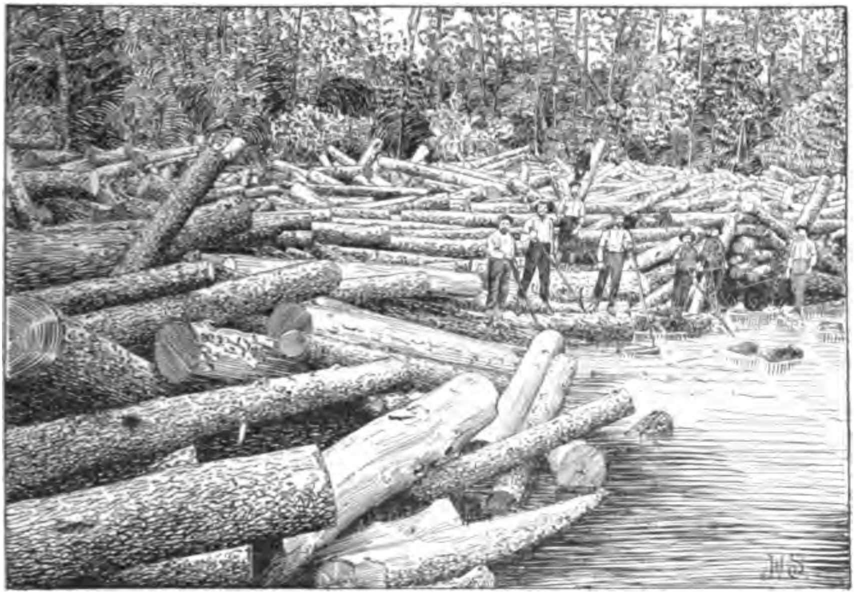

FIG. 17.—River drivers at work on a log jam. Minnesota.

Besides lumber, the best sawmills produce great quantities of lath and shingles, made either from small logs called "bolts," cut specially for that purpose, or from slabs, edgings, and other pieces of wood which might otherwise be wasted. But in spite of every effort to prevent waste in the mill by using sawdust and other refuse for fuel, and in other ways, very many thousands of tons of wood a year are thrown into great burners as the cheapest method of getting it out of the way.

When the lumber has been sawed it may be piled and seasoned in the yard or kiln-dried before it is sent to market or sold at the mill. Some sawmills on Puget Sound are built on piles over the water, so that the lumber is loaded into vessels directly from the saws. Others load their product on the cars and distribute it by rail. Still others on the Pacific slope float their timber away in a narrow wooden trough called a "flume," through which flows a rapid stream of water. These flumes are sometimes over 40 miles in length, and cost almost as much to build as a railroad. Many sawmills have connected with them planing mills or woodworking factories of other kinds, so that the rough lumber from their saws is changed into the form of a finished product before it reaches the market.

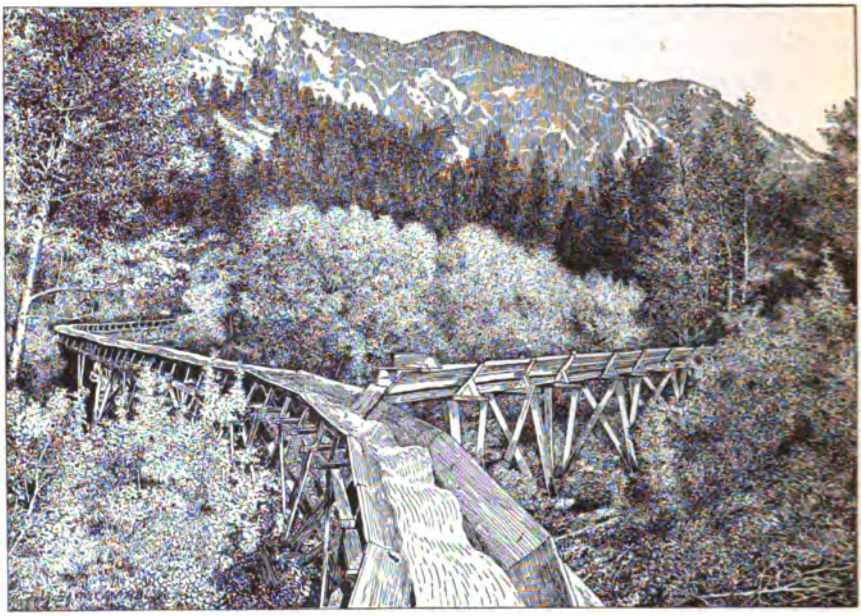

FIG. 18.—Lumber flume in the mountains. California.

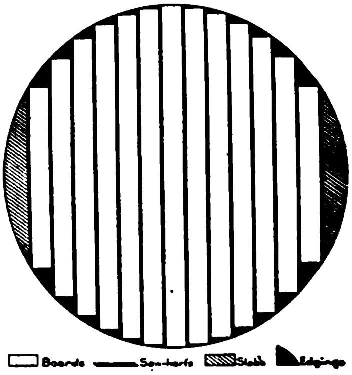

FIG. 19.—Diagram to show the sawing of a log.

Waste in lumbering.—This is very briefly the way in which a tree gets into the market at the end of its life. At every step there is some waste. Although it may be sound throughout, the lumbermen in the woods can take but a portion of it, often leaving a part of the trunk and all of the top to rot on the ground. When each log comes to the saw there is a further loss of nearly all the slabs and edgings and all the sawdust that is not used for fuel. On the average it is doubtful whether more than half of the cubic contents of a standing tree is finally used. As prices rise and as conservative lumbering comes to be generally practiced, the greater part of this enormous loss will be avoided, but it can probably never cease altogether.

PLANTING.

It has often been proposed to plant trees in order to repair the damage done to the forests by the lumbermen. Tree planting is most useful in all the treeless or scantily wooded portions of our country where planted trees will grow, and wherever forests have been very severely injured or destroyed, but it is generally far too expensive to take the place of conservative lumbering in regions already forested. An acre of growing natural forest can be bought in nearly every forested part of our country for less than it would cost to plant, 4 feet apart, an acre of seedlings a few inches high. The true way to save the forests is not to-plant new ones, but to protect and rightly use those which are standing now. The extension of the forest to regions which are without it is a most important task, but it must not be confounded with the conservative use of the forests now standing. For such use there is no substitute whatever.

THE WEATHER AND THE STREAMS.

The central point of public interest in forestry in the United States was until recently the influence of forests on climate. It is natural that the connection between the immense forests and vast plains and the wonderfully various climates of this continent should have awakened attention. It is a matter which is easily written and talked about without any thorough understanding of forestry itself, and in this it differs from other branches of the subject. In dealing with the weather one touches a thing which affects the daily life of everyone, and which, to very many, holds the balance between poverty and prosperity. It is therefore unfortunate that so much of the writing and talking upon this branch of forestry has had little definite fact or trustworthy observation behind it. The friends and the enemiesof the forest have both said more than they can prove. Both have tried to establish the truth of their opinions by referring to observations of temperature and rainfall which cover too short a time to prove anything, or by hearsay and general impressions, which are not to be trusted in such matters. Such discussions make nothing clear except that the pith of the matter has not been reached by either party.

FORESTS AND CLIMATE.

The discussion of forest influence on climate began in this way. When the French revolution broke out in 1789, the old restrictions on the management of private forests were removed. A wholesale cutting of these timberlands promptly followed, and as early as 1792

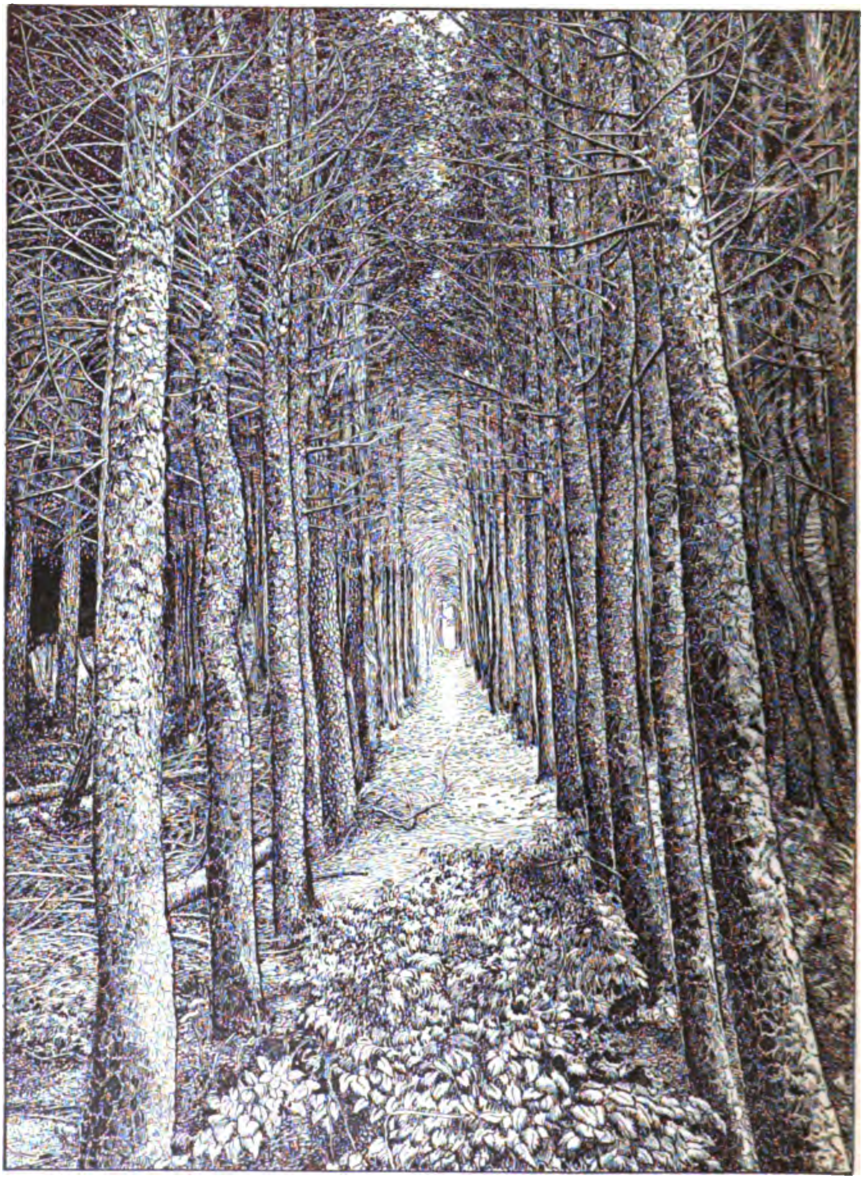

FIG. 20.—European larch grove in western Minnesota. Cost of planting per acre 17 years ago, $64.45. Present value per acre, $484.

the consequences began to be observed. The question of forests and climate was then raised for the first time; but questions of this kind can not be answered without long and careful observations. Such observations were begun by Becquerel in France and Krutsch in Germany about the middle of the last century, but it was not until 1867 that a satisfactory way of making them was devised. This was the system of double stations—one within the forest, the other at a distance in the open. It was first put in operation by Professor Ebermayer, now of the Bavarian Forest School. By this means the amount of moisture and heat in the forest may be compared with that in the open, and in the end a full and satisfactory answer will probably be reached.

FIG. 21.—The forest cover. Oregon.

In order to find how great the influence of forests on climate may be, we must first see what are the factors which make climate. Then we may ask which of these factors can be affected by the forest, and in what way.

The climate of any place on the earth's surface results from the action of the sun's heat upon it. Climate is the average condition of the weather. It depends, first of all, on the distance of a place from the equator and its elevation above the sea. Secondly, it depends on the distribution of land and water, the relief of the land, whether flat, hilly, or mountainous, and the character of the surface covering. These are all connected with the temperature in a special manner. Lastly, it is affected by the winds and the moisture of the atmosphere. Now, it is clear that of all these factors of climate the forest can influence only the wind, the moisture, and the surface covering; but heat (with which the surface covering has so much to do), moisture, and wind are the three things which change when we say that the weather changes. These are just the points where a change due to the forest would have most effect on daily life. The influence of the forest is exerted upon them in two ways:

First. The forest cover intercepts the rain and the rays of the sun, checks the movement of the air, and reduces the radiation of heat at night.

Second. The waste from the trees and from certain plants which grow only in their shade forms the forest floor, which has much to do with the movement of water on the ground and within it. The influence of the forest cover and the forest floor appears in the temperature of the air, the evaporation of water, the rainfall, and the course of the rain water after it has reached the earth.

EFFECT OF FOREST COVER ON TEMPERATURE.

So far as the influence of the forest is concerned, the temperature of the air is affected chiefly by the forest cover. The leaves, which compose the greater part of the cover, contain from 50 to 70 per cent of water. More heat is required to raise the temperature of a pound of water one degree than for a pound of almost any other substance, and so it happens that bare soil or rock exposed to the rays of the sun becomes heated many times faster than the water in the leaves. While the heated rock or soil was warming the air about it the forest cover would still be absorbing heat and keeping the air below it cool. The leaves of the cover also tend to cool the air by transpiration, which is the evaporation of water from the leaves. This is true because heat is required to change water into water vapor, and a part of the sun's heat is taken up for this purpose. In these two ways the forest cover acts somewhat like a surface of water.

The growth of the tree itself also helps to cool the air. When the leaves take carbonic-acid gas from the air they break it up and force its carbon into new chemical compounds, which are then stored away as new material in the tree. So with water and the other substances upon which the plant feeds. But the elements are less at ease in these new compounds, and heat is required to force them to make the change. When we burn wood for fuel we are simply getting back again the heat which was used to bring about this change. So we may say roughly that the air about the tree during its lifetime has been deprived of as much heat as would be given off if the whole tree were burned.

The effect of the cooler air of the forest is felt to some distance in the open country. During the day, in calm summer weather, when the air is warmer than the tree tops, it is gradually cooled by contact with the cooler leaves and twigs. In cooling it becomes heavier and falls toward the ground. A rising current of warmer air is formed to supply its place, and so the colder air flows off along the surface into the open country and causes local breezes. At night the air currents are reversed. The air in the forest is then warmer than the air outside, because the cover checks the radiation of heat, and so the colder air moves from the open country toward the woods. In these ways the influence of the forest is felt at a distance.

The amount of this cooling of the air has been measured in certain places. It is naturally found to be greatest in summer; while in winter and at night the air in the tree tops is a little warmer than in the open. It is important to add that the cooling effect of the forest is greater than the average in the mountains, and less in the plains.

EXTREMES OF HEAT AND COLD.

The extremes of heat and cold are moderated by the forest. Observations on this point have been made, for example, in Bavaria and Württemberg. They showed that the lowest temperature of every day in the year was higher, on an average, by nearly 2° in the forest, while the highest temperature was lower by nearly 4°. The greatest heat of the day in the summer was 7½° less in the forest than outside. Prussian observations showed that for ten years the greatest heat of the day in July was, on an average, nearly 6° lower in the forest, and the greatest cold of the night in January nearly 3° less than outside. It should not be forgotten that the latitude, the elevation, and the exposure had a powerful influence on these differences, which are also greatly affected by the kind of trees and the density of the forest.

It must be borne distinctly in mind that the figures given above are reliable only for the places in central Europe where they were observed. But the principles on which they depend are just as true in America as they are in Europe. Natural laws are the same the world over. It is safe to conclude, then, that in the United States the forest modifies the temperature of the air in certain ways and for certain reasons, both of which we have seen. Just how great this influence is in different parts of this continent it is as yet impossible to tell. But it is probably greater on the average than these observations indicate, for two reasons: First, the extremes of heat and cold, moisture and dryness, are much greater here than in central Europe, and changes are more sudden; second, in most of the double stations mentioned above the station outside the forest was within less than a mile of it, and thus likely to be influenced by the cooler air currents flowing from it; that is, the real effect of the presence or absence of woods over large stretches of country is probably greater than these observations show.

A system introduced in Austria is expected to give a clearer idea of the distance to which the forest influence reaches. It consists of lines of stations beginning in the center of a large forest and extending step by step into the open country beyond.

MOISTURE IN FOREST AIR.

The moisture of the air is greater in the forest than outside. The absolute quantity of water vapor in a cubic foot of air is generally the same in both places, but the forest air is cooler, and therefore its relative humidity is greater. Relative humidity is the amount of vapor actually in the air, expressed as so much per cent of all it could hold at the same temperature. The amount of water that the air can hold changes when the temperature changes, but in such a way that air cooled until it is only half as warm as before can hold much less than half as much vapor. If a hot and a cold stream of air, both saturated with water vapor, meet and mix, the mixture can no longer hold as much vapor as the two streams separately, and a part is condensed, usually in the form of rain or snow. German and Swiss observations have shown that the average humidity is greater in the forest by from 3 to 10 per cent. This difference increases with the altitude above sea level and the density of the forest cover. The increase of humidity explains why dew is more frequent in the neighborhood of the forest than at a distance.

EVAPORATION.

The water which falls to the earth from the atmosphere had first to be evaporated, so that year by year the quantity of water which the air takes from the surface of the globe by evaporation is the same as that which falls upon it in the shape of rain, hail, snow, and dew. The effect of the forest on this great movement of water is to detain more of it on those portions of the earth which are sheltered by trees. It does this partly by tending to increase the rainfall, but its effect in lessening the loss of water through evaporation is probably much more important. The colder and moister air of the forest has less capacity for taking up water vapor than that of the open country. It is also quieter, which means that the winds are less active in replacing saturated air with air which can still take up more water. The forest acts powerfully in checking the force of the winds because the elastic swaying of the twigs and branches is a very effective hindrance to the movement of the air. Strong winds, although they are often dangerous in themselves, do most harm by drying up the moisture in the soil and in the plants which grow from it. Thousands of miles of wind-breaks have been planted by farmers in the western parts of this country to protect their crops and homes against the wind. These wind-breaks serve a most useful purpose, but they are naturally far less effective in preventing evaporation than the forest itself. So great is the power of the latter that direct observations made in Bavaria and Prussia showed that evaporation from a free surface of water in the forest was only 40 per cent of that in the open.

The presence or absence of leaf mold has a powerful effect on the amount of evaporation from forest soil. The experiments of Doctor Ebermayer, a famous German forest meteorologist, showed that evaporation from forest soil without a layer of mold was 47 per cent of that from soil in the open, while with a layer of mold it was less than half as much, or 22 per cent. The greater the altitude above the sea the greater is the effect of the forest in preventing evaporation. This is a powerful reason for preserving mountain forests at the headwaters of streams, especially in the Rocky Mountain regions of the United States. Evaporation is there so active that great banks of snow lying in the full glare of the sun often disappear without melting even enough to moisten the ground on the hillsides below them. Vast quantities of water evaporate in this way without ever reaching the streams. Measurements made by the Geological Survey show that evaporation from snow may be four or five times as great as from water under like circumstances.

RAINFALL.

The causes of rain are for the most part wholly beyond the reach of influence from the forest. Such are the great currents of warm and cold water in the ocean, the direction of the prevailing winds, and the presence or absence of mountain ranges. But there are two reasons which lead us to believe that forests do affect the rainfall. These are their colder and moister air, and the resistance which they offer to the motion of the winds. A great number of observations has been made in different parts of the world to discover how much the rainfall really is affected by the forest, but for several reasons no generally accepted result has yet been reached. In the first place, accurate observations on rainfall are not easy to make. The height above the ground at which a rain gauge is placed affects it very seriously. A variation of 10 feet in height will often make more difference in the amount of rain caught than most observers claim for the whole action of the forest. The rainfall of two stations at unequal heights above sea level is sometimes wrongly compared, because the difference in rainfall may be caused by the difference in altitude. Finally, the best observations that have been made point to different conclusions. For example, measurements taken in Prussia go to show that there is an increase of rain over the forest, and that it is greater the higher the station. Thus, near the level of the sea it was only 1.25 per cent greater than over the open country, while at altitudes between 2,000 and 3,000 feet it reached 43 per cent. Observations made at Nancy, in France, which lies about 700 feet above the sea, show an average yearly increase of 16 per cent. The Bavarian observations, on the contrary, do not indicate more rain over the forest. The best evidence at hand fails to show a decrease in rainfall over the United States in the last hundred years, in spite of the immense areas of forest that have been burned and cut. But it should not be forgotten that most of those areas have grown up again, first with brush, and afterwards with trees, so that the proportion of land covered with leaves is still very large in all that part of the country which was once under forest. In India, again, a large amount of statistics has been collected which leads to the conclusion that forests do influence rainfall. The truth probably is that more rain falls over the forest than over open country similarly placed, but how much more it is impossible to say. The excess falls chiefly in the form of summer showers. One of the best authorities has estimated the difference at 10 per cent.

FALLEN RAIN.

Whatever doubt there may be about the action of the forest in producing rain, there is none about its effect on rain water after it has fallen. When rain falls over a dense forest from less than one-tenth to about one-fourth of it is caught by the trees. A small part of this water may reach the ground by running down the trunks, but the greater part of it is evaporated, and so increases the humidity of the air. That which passes through the crowns falls upon the forest floor, which sometimes has an absorbing power so great that it can hold for a while a rainfall of 5 inches. Yet this water does not remain in the porous floor, but in the end runs off into the streams, or is evaporated, or sinks into the ground. That which gets into the ground is either taken up by the roots or goes to feed the springs and water courses.

Rain which falls over a bare slope acts differently. It is not caught by the crowns nor held by the floor, nor is its flow into the streams hindered by the timber and the fallen waste from the trees. It does not sink into the ground more than half as readily as in the forest, as experiments have shown. The result is that a great deal of water reaches the streams in a short time, which is the reason why floods occur. It is therefore true that forests tend to prevent floods. But this good influence is important only when the forest covers a large part of the drainage basin of the stream. Even then the forest may not prevent floods altogether. The forest floor, which has more to do with the fallen rain water than any other part of the forest, can affect its flow only so long as it has not taken up all the water it can hold. That which falls after the forest floor is saturated runs into the streams almost as fast as it would over bare ground.

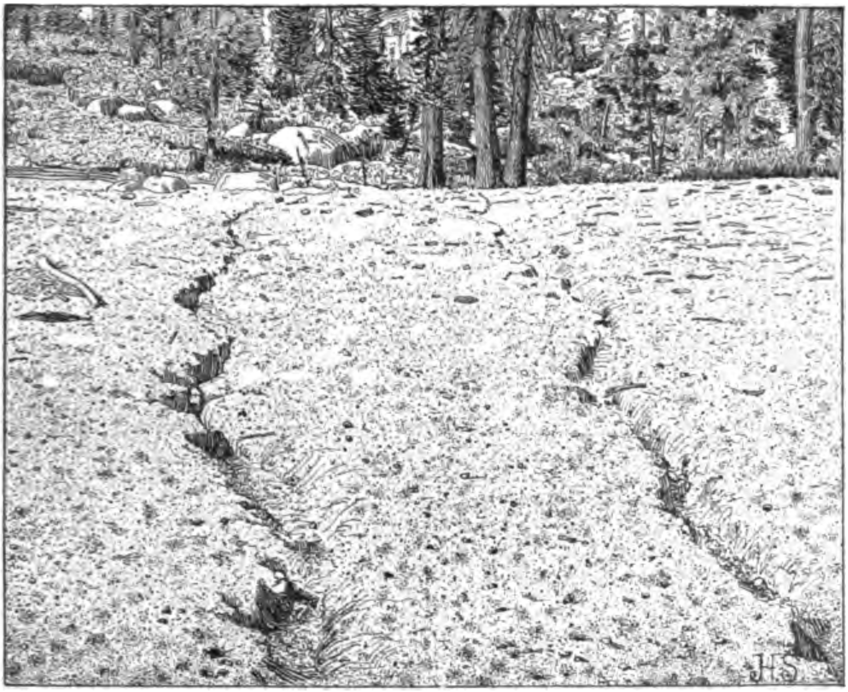

FIG. 22.—Beginnings of erosion in soil tramped bare by stock. Sierra Nevada Mountains, California.

An unforested drainage basin in the San Bernardino Mountains of southern California was found by the Forest Service to discharge the rain it received more than twice as rapidly as similar forested basins near by. In consequence the stream in the former went dry, while the streams in the latter were still flowing abundantly.

In these ways it happens that in mountain countries, where floods are most common and do most harm, the forests on the higher slopes are closely connected with the prosperity of the people in the valleys below.

Water in motion was nature's most powerful tool in shaping the present surface of the earth. In places where the slopes are steep, the structure of the ground loose, and the rainfall abundant, water may work very rapidly in cutting away the heights and filling the valleys. The destruction of the forest in such a region exposes the surface to the direct action of falling rain and is certain to be followed by the formation of torrents. The danger is greatest when the soil has been laid bare by the browsing and the hoofs of grazing animals, among which sheep and goats are especially destructive, or where the forest floor has been burned away.

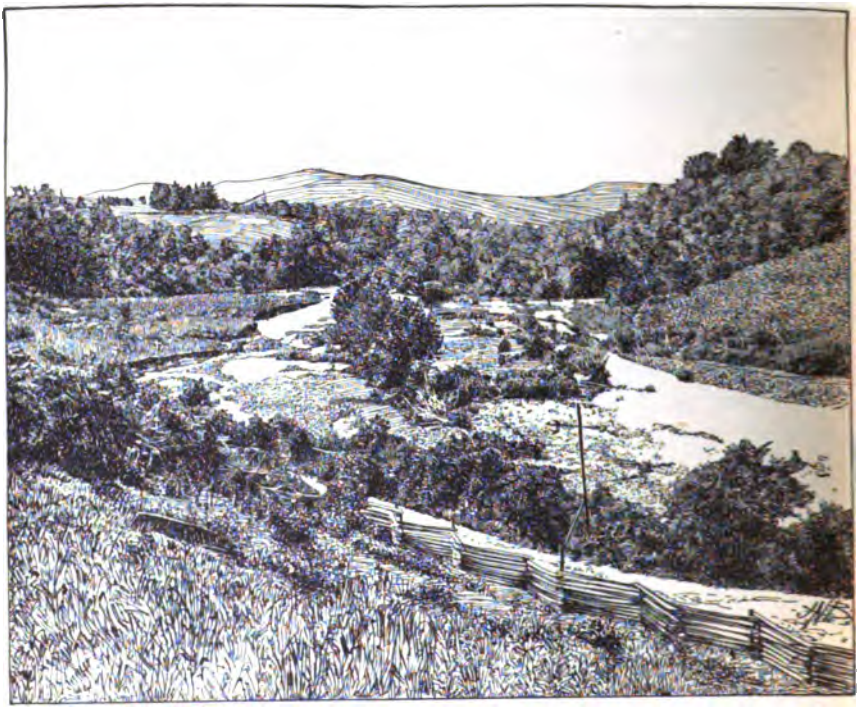

FIG. 23.—Rich bottomland washed out by floods. North Carolina.

When these conditions are both present, as in parts of the Sierra Nevada Mountains of California, of the Cascade Range in Oregon, and in many other parts of the West, the prosperity of the valleys is in serious danger. Fire and overgrazing on the mountains combine to endanger the future water supply of irrigated or irrigable areas in the valleys below. When rain falls over mountains which have so been deprived of their natural protection it is no longer caught and held back by the trees and the forest floor. The roots, which were once the strongest means of binding the soil together, now are gone and leave it without protection against the rushing water. Heavy rains or sudden thaws swell the streams with marvelous quickness, and give them a wonderful power to cut away their banks. Where the waterway is very steep such a flood often carries with it many times its own weight of earth and stones. As it nears the valley it breaks from its bed and makes new channels, or spreads over the lowlands. The current loses its swiftness, and its load of stones and sterile earth sinks to the bottom, the heavier pieces first. Where it falls the beds of rivers are filled up and fertile lands are covered with pebbles and sand.

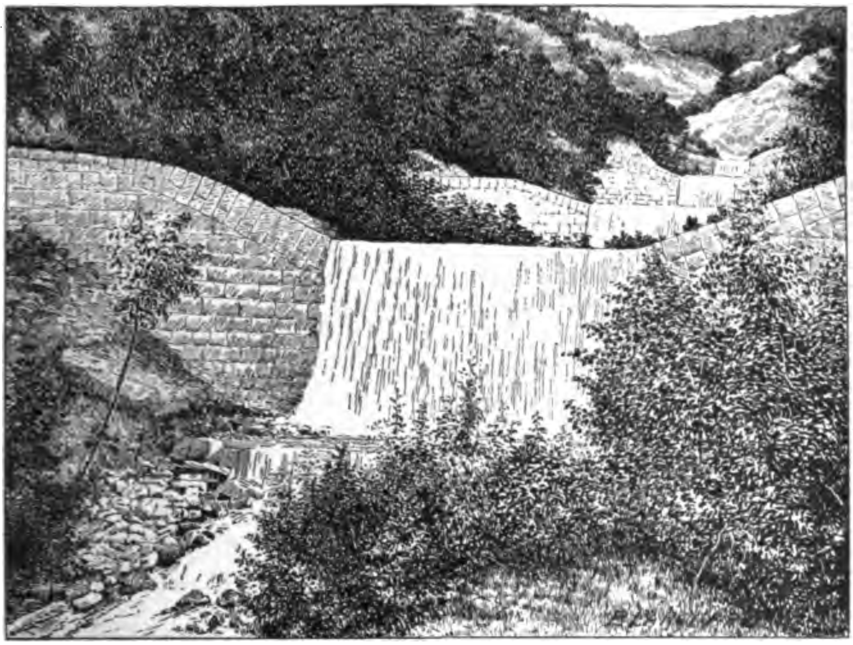

FIG. 24.—Plantation of European alder in the bed of a torrent controlled by dams. This torrent is now extinct. Alps of southern France.

For a time after such a flood the streams are usually low, because the water which should have fed them for weeks or months has run off in a few days. This may be quite as serious a matter for the farmers as the destruction of their fields, as, for example, in places like southern California, where the crops depend on irrigation with the water of streams which rise in the mountains. Torrents have begun to form there in the San Bernardino Mountains, and have already carried stones and sand into the orange groves, and even into the towns of the San Gabriel Valley. Before the water of the San Gabriel River was so largely taken out for irrigation it was rapidly cutting away the fertile land on either side of its shifting bed, and it seemed likely that serious loss .of property would follow. This is the direct result of fire and grazing in the mountains.

The pasturage of sheep in the Alps of southern France was the chief cause of the destructive torrents with which the French Government has been struggling for many years. The direct loss to the French people has been enormous, and in addition the work of correction alone has cost upward of $35,000,000. Although wonderfully successful hitherto, it is still far from finished.

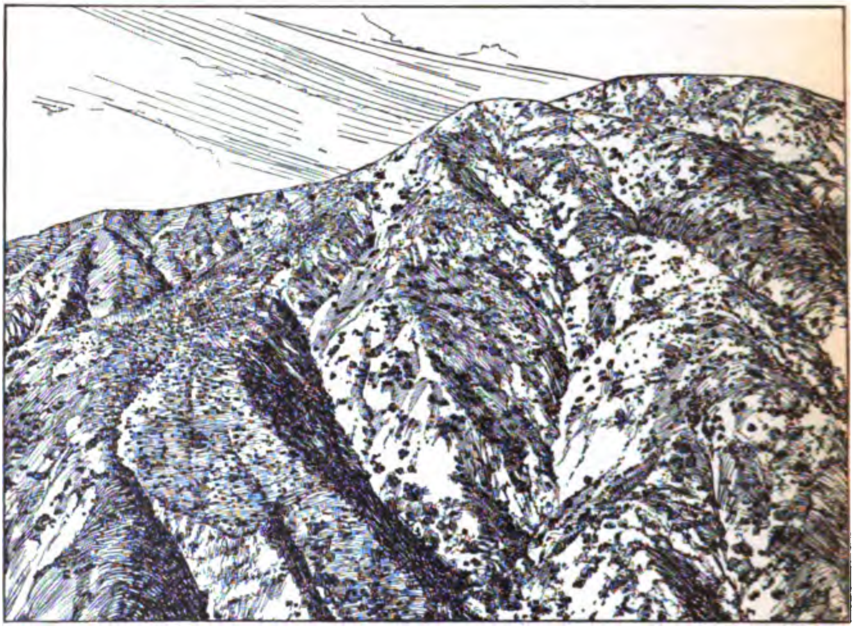

FIG. 25.—Unforested watershed in the San Bernardino Mountains. Southern California.

FORESTRY ABROAD AND AT HOME.

FORESTRY ABROAD.

Except China, all civilized nations care for the forest. Until recently the United States ranked nearly with China in this respect, and our country still remains far behind the progressive modern nations in nearly all that relates to the protection, preservation, and conservative use of the forest. Japan has a well-developed forest service and a national forest school. In Austria, Italy, and Norway and Sweden government forestry is a well-established portion of the national life. Turkey, Greece, Spain, and Portugal give attention to the forests. Russia, dealing like ourselves with vast areas of forests in thinly peopled regions, but by methods wholly different from our own, is drawing enormous revenues from the systematic care and use of the forests. In Germany the scientific treatment of forests has reached, perhaps, its highest development. The foresters of France have perfected a most practical and effective general system of forestry and have created the difficult art of controlling the floods of mountain torrents by planting trees. The Republic of Switzerland, by the use of methods most instructive to citizens of the United States, has developed a type of government forest policy more worthy of our attention and imitation than any other in Europe. In Australia and New Zealand forestry has already made important advances. In Canada the English have made real progress in forestry. The Government sells the timber from its forests, but retains possession of the lands and employs fire guards. At the Cape of Good Hope they have an excellent forest service. In British India they have met and answered many questions which still confront the American forester, and in a little more than thirty years have created a forest service of great merit and high achievement. The United States has scarcely yet begun.

THE FOREST IN EARLY TIMES.

In very early times the forest was preserved for the game it contained. Forestry then meant the art of hunting, and had very little to do with the care of trees. Even the word "forest," which really comes from the Latin *foris*, meaning out-of-doors, was thought in England to be derived from the fact that it was a place given up to wild animals *for rest*. But gradually the forest came to be considered more than the game, and the serious study of forestry began.

MODERN FORESTRY.

Forestry as a science is of comparatively recent origin, although a work in which all the European trees are described was one of the earliest printed books. Until the end of the eighteenth century forestry was discussed chiefly by men who were either scholars or practical woodsmen, but who were not both. Then appeared Hartig and Cotta, two men who united these points of view, and their writings are at the base of the whole modern growth of the subject. Both were German. Each covered the whole field as it was then understood, and together they exerted an influence which has not been approached by any other authors since. From Germany their teaching spread to France, and early in the nineteenth century their doctrines were introduced into the French Forest School at Nancy by Lorentz, who, with his successor, Parade, was the founder of modern forestry in France.

Under the feudal system, which was finally destroyed in France by the revolution of 1789, the forest was the property of the feudal lord. In order to make the life of his serfs, who were useful both as taxpayers and as fighting men, easier, and so increase their number, he gave them the privilege of taking from his forest the wood which they required. For similar reasons the wealthy religious houses, like that of the Grande Chartreuse, made grants of land and of rights in the forest. But after a time the number of peasants increased so much that their wants absorbed nearly the whole produce of the woodlands. Then it was found necessary to limit the prescriptive rights to forest products by restricting them to certain parts of the forest, or to make an end of them by exchanging them for the absolute ownership of smaller areas. Thus many of the communities, to which, and not to individual peasants, these rights belonged, came to possess forests of their own. But the communes, as they were called, managed their forests badly, and about three hundred years ago the Government was forced to intervene. Under the management of officers of the government forest service, the results from the communal forests have been excellent. At present these forests not only supply fuel to the villages which own them, but in some cases they produce enough to pay all the village taxes as well.

Germany.—Germany still holds the high position in forest science which began with Hartig and Cotta. The German forest schools, of which there are seven of the higher grades, are still among the very best, and the study of forestry, both in the schools and in the forest experiment stations, is eagerly pursued. The forests in Prussia, Saxony, and other German States are admirably managed, and yield important returns. The total value of the German forests, public and private, is said to be about $4,500,000,000.

France.—Forestry in France has long been associated with the names of famous men. Henry of Navarre and his friend and minister, Sully; Palissy, the great potter, who called the neglect of the forest prevalent in his time "not a mistake, but a calamity and a curse for France;" Colbert, the minister of Louis XIV; the botanist Duhamel du Monceau; Buffon, the celebrated naturalist, are among the men to whom France owes the rise and progress of her present excellent forest policy. Their peculiar service was to lay the foundation, both in law and in public opinion, upon which modern forestry in France now rests.

The forests of the French Government are admirably managed. They cover only about 2,750,000 acres, but they yield a net return each year of more than $2 per acre. Besides handling their national forests with great intelligence and success, the French foresters have done much for the general progress of forestry. They developed the art of reforesting denuded mountains, and were the first to plant trees on moving sand dunes along the seashore. More than 150,000 acres of these dunes, which once were blown about by the wind until they overwhelmed great stretches of fertile ground, and even threatened to bury whole towns, are now covered with forests of pine, and produce great quantities of turpentine, lumber, and charcoal.

Switzerland.—In Switzerland forestry received attention from very early times. Nearly two hundred years before the discovery of America the city of Zurich began to make rules for the protection and management of the Sihlwald, a forest which it still owns, and which now yields an annual return of about $8 per acre. In the Canton of Bern a decree of the year 1592 warned the people against the wasteful use of timber and provided for the protection of the forest along various lines. It also directed that for every tree cut down a young one should be planted in its place. It is curious to find this mistaken prescription for the ills of the forest already in fashion more than three centuries ago. To save the forest every old tree must be replaced by *many* young ones.

The first general forest law of Bern was passed as early as 1725. It embodied the most important principles of wise forest legislation as we know them to-day. But this was only one of a long series of forest laws in which, from the beginning, the idea of the importance of the forest to others besides its owner became steadily stronger. The citizens of Bern have grown ever more willing to place restrictions on themselves for the benefit of the Commonwealth.

There were great floods in Switzerland in 1834, and they were the cause of a general awakening of interest in forestry. Somewhat later a federal forest commission was appointed. Since the appearance of its final report in 1861 the progress of forestry in Switzerland has been steady. In 1875 a federal forest inspector was appointed, and a year later the first Swiss forest law was passed. This law does not extend to the whole of Switzerland, but only to the Alps and the steeper foothills. In a country of steep mountains it is of first importance to guard the forests on the higher slopes. Consequently all the forests on these higher lands which serve to protect the lowlands against floods, avalanches, and other similar dangers of wind and weather are put in charge of the Swiss federal forest service.

A great saying of Landolt: "Our forest laws," said Elias Landolt, a great and simple man, whose name stands first among Swiss foresters, "are intended to work more through instruction, good example, and encouragement than by severe regulations. This method is somewhat slower than one which should involve harsher measures, but the results achieved are more useful and lasting. When forest owners do something because they are convinced of its usefulness it is done well and with an eye to the future, but what they do under compulsion is done carelessly and neglected at the first opportunity. What they have come to learn in this way and have recognized as good will be carried out, and that better and better from year to year."

British India.—For many years after the British conquest forestry in India made very little progress. Much time was wasted in half measures, until in 1856 Doctor (now Sir Dietrich) Brandis was put in charge of the teak forests of Pegu. He acted at once upon the idea of preserving them by making them pay. At first the output of teak had to be somewhat restricted, much against the will of the timber merchants of Rangoon, who protested that the business of their city would be ruined. But after this momentary check the teak trade of Rangoon grew until it was far greater than ever before, and it is now a chief and increasing source of the prosperity of that city.

The appointment of Doctor Brandis was the beginning of the Indian forest service. In 1866 he was made inspector-general of forests, and from that time progress was rapid. The Indian forest service now has nearly 300 superior officers and over 10,000 rangers and forest guards. It has charge of about 200,000 square miles of forest, and produces a net revenue, after all expenses have been paid, of about $3,000,000 a year. In addition, the forests furnish to peasant holders of forest rights products whose value is estimated to be considerably greater than the whole cost of the forest service. About 30,000 square miles are effectively protected against fire, at an average yearly cost of less than half a cent per acre. These admirable results are especially interesting because India is like the United States in the great extent and variety of her forests and in the number and fierceness of forest fires.

FORESTRY AT HOME.

The forests of the United States cover an area of about 699,500,000 acres; or more than 35 per cent of the surface of the country. Before so large a part of them was destroyed they were perhaps the richest on the earth, and with proper care they are capable of being so again. Their power of reproduction is exceedingly good.

In the Northeastern States, and as far west as Minnesota, once stretched the great white pine forest from which, since settlement began, the greater part of our lumber has come. South of it, in a broad belt along the Atlantic and the Gulf coasts, lies the southern pine forest, whose most important tree both for lumber and naval stores is the southern yellow pine. In the Mississippi Valley lies the interior hardwood forest of oaks, hickories, ashes, gums, and other hardwood trees. It is bordered on the west by the plains, which cover the eastern slope of the continental divide until they meet the evergreen Rocky Mountain forest, which clothes the slopes of this great range from the Canadian line to Mexico. Separated from the Rocky Mountain forest by the interior deserts, the Pacific coast forest covers the flanks of the Sierras, the Cascades, and the Coast ranges. Its largest trees are the giant sequoia and the great coast redwood, and its most important timber is the fir.

The forests of the Philippine Islands cover an area of more than 40,000,000 acres. Their timbers, almost wholly different from those of the United States, are exceedingly valuable, both as cabinet woods and as construction timber. An efficient forest service was organized in 1898, and following its reorganization in 1902 a new and excellent forest law was passed in 1904. The Philippine forest service costs but half as much as the revenue received from the forests of the islands.

The island of Porto Rico contains a national forest reserve, the site of which was once covered with valuable hardwoods; but this forest has been much abused. Porto Rico, like the Philippines, has many kinds of wood valuable for cabinetmaking.

The settler and the forest.—When the early settlers from the Old World landed on the Atlantic coast of North America they brought with them traditions of respect for the forest created by generations of forest protection at home. The country to which they came was covered, for the most part, with dense forests. There was so little open land that ground had to be cleared for the plow. It is true that the forest gave the pioneers shelter and fuel, and game for food, but it was often filled with hostile Indians, it hemmed them in on every side, and immense labor was required to win from it the soil in which to raise their necessary crops. Naturally, it seemed to them an enemy rather than a friend. Their respect for it dwindled and disappeared, and its place was taken by hate and fear.

The feeling of hostility to the forest which grew up among the early settlers continued and increased among their descendants long after all reason for it had disappeared. But even in the early days far-sighted men began to consider the safety of the forest. In 1653 the authorities of Charlestown, in Massachusetts, forbade the cutting of timber on the town lands without permission from the selectmen, and in 1689 the neighboring town of Malden fixed a penalty of 5 shillings for cutting trees less than 1 foot in diameter for fuel. An ordinance of William Penn, made in 1681, required that 1 acre of land be left covered with trees for every 5 acres cleared. But these measures were not well followed up, and the needless destruction of the forest went steadily on.

First steps in forestry.—More than a hundred years later, in 1795, a committee of the Society for the Promotion of Agriculture, Arts, and Manufactures in New York made a report on the best way to preserve and increase the growth of timber. Four years afterwards Congress appropriated $200,000 for the purchase and preservation of timberlands to supply ship timbers for the navy, and in 1822, with the same object in view, it authorized the President to employ the army and navy to protect and preserve the live oak and red cedar timber of the Government in Florida. Since that time more and more attention has been given to the forests. In 1828 Governor De Witt Clinton, of New York, spoke of the reproduction of our woods as an object of primary importance, and in the same year the Government began an attempt to cultivate live oak in the South for the use of the navy. Three years later an act was passed which is still almost the only protection for the much-abused forests of the public domain.

In 1872 the Yellowstone National Park was established, and in 1873 Congress passed the timber-culture act, which gave Government land in the treeless regions to whoever would plant one-fourth of his claim with trees. In 1875, the American Forestry Association was formed in Chicago through the efforts of Dr. John A. Warder, who was one of the first men to agitate forest questions in the United States. In the centennial year (1876) Dr. Franklin B. Hough, perhaps the foremost pioneer of forestry in America, was appointed special agent in the Department of Agriculture. This was the beginning of educational work in forestry at Washington. Soon afterwards Congress began to make appropriations to protect the public timber, but nothing was done to introduce conservative forest management.

About this time forest associations began to be established in the different States, the most influential and effective of which has been that in Pennsylvania. The States also began to form forest boards or commissions of their own.

In 1888 the first forest bill was introduced in Congress. It failed to pass, but in 1891 an act was passed which was the first step toward a true policy for the forests of the nation. The first step toward national forestry is control of the national forests. This act, whose chief purpose was to repeal the timber-culture act, contained a clause which authorized the President to reserve timber lands on the public domain, and so prevent them from passing out of the possession of the Government.

The public domain.—In all the States and Territories west of the Mississippi except Texas, and in Ohio, Indiana, Illinois, Michigan, Wisconsin, Florida, Alabama, and Mississippi, all the land originally belonged to the Government. This was the public domain. It has gradually been sold or given away until in many of the States it has all or nearly all passed to other owners. But it still includes more than 470,000,000 acres, or nearly one-third of the United States, not including the Territory of Alaska, which has an area of about 350,000,000 acres. A large part of the public domain has been surveyed by the Government and divided first into squares 6 miles on each side, called townships, then into squares of 1 mile, called sections, and these again into quarter sections and smaller divisions. The lines which mark these divisions are straight and at right angles to each other. When any part of the public domain is reserved or disposed of it is usually located by reference to these lines.

Federal forest reserves.—When power was given the President to make forest reserves, the public domain still contained much of the best timber in the West, but it was passing rapidly into private hands. Acting upon the wise principle that forests whose preservation is necessary for the general welfare should remain in Government control, President Harrison created the first forest reserves. President Cleveland followed his example. But there was yet no systematic plan for the making or management of the reserves, which at the time were altogether without protection by the Government. Toward the end of President Cleveland's second administration, therefore, the National Academy of Sciences was asked to appoint a commission to examine the national forest lands and report a plan for their control. The academy did so, and upon the recommendation of the National Forest Commission so appointed, President Cleveland doubled the reserve area by setting aside 13 additional forest reserves on Washington's Birthday, 1897.

The Cleveland forest reserves awakened at once great opposition, and led to a general discussion of the forest policy. But after several years of controversy widespread approval took the place of opposition, and at present the value of the forest reserves is generally recognized.

The recommendations of the National Forest Commission for the management of the forest reserves were not acted upon by Congress, but the law of June 4, 1897, gave the Secretary of the Interior authority to protect the reserves and make them useful. The passage of this law was the first step toward a national forest service. The second step was the act of Congress, approved February 1, 1905, which transferred the control of the national forest reserves from the Department of the Interior to the Department of Agriculture. This act consolidated the Government's forest work, which had been divided between the General Land Office and the Bureau of Forestry, and secured for the reserves the supervision of trained foresters.

President McKinley and after him President Roosevelt continued to make forest reserves. The latter introduced a system of examining the proposed forest reserves, so that now their boundaries are better located than ever before. Under him great progress has been made by the Government in bringing about the practice of forestry by forest owners and in awakening the great lumber interests, as well as the people in general, to the dangers of forest destruction.

The forest reserves lie chiefly in high mountain regions. They are 62 in number, and cover an area (January 1, 1905) of 63,308,319 acres. They are useful first of all to protect the drainage basins of streams used for irrigation, and especially the watersheds of the great irrigation works which the Government is constructing under the reclamation law, which was passed in 1902. This is their most important use. Secondly, they supply grass and other forage for many thousands of grazing animals during the summer, when the lower ranges on the plains and deserts are barren and dry. Lastly, they furnish a permanent supply of wood for the use of settlers, miners, lumbermen, and other citizens. This is at present the least important use of the reserves, but it will be of greater consequence hereafter. The best way for the Government to promote each of these three great uses is to protect the forest reserves from fire.

State forestry.—Many of the States have taken great and effective interest in forestry. Among those which have made most progress are New York and Pennsylvania. New York has a state forest preserve of 1,436,686 acres, and Pennsylvania one of 700,000 acres. Michigan, Minnesota, and other States are rapidly following their example.

In 1892 the first example of systematic forestry in the United States was begun at Biltmore, in North Carolina. It is still in successful operation.

The first professional foresters in the United States were obliged to go abroad for their training, but in 1898 professional forest schools were established at Cornell University, in New York, and at Biltmore, in North Carolina, and they were followed by the Yale Forest School in 1900. Others have sprung up since. At present, thorough and efficient training in professional forestry can be had in the United States.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 359.

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CANNING VEGETABLES IN THE HOME.

BY

J. F. BREAZEALE,

BUREAU OF CHEMISTRY.

[Reprint of January, 1910.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., March 18, 1909.

SIR: I have the honor to submit herewith a manuscript on domestic methods of canning vegetables. Mr. Breazeale, of the Laboratory of Vegetable Physiological Chemistry of this Bureau, has had a large experience along this line in the actual preservation of vegetables and is thoroughly acquainted with the methods which have been developed in the Bureau of Chemistry for securing complete sterilization. As a Farmers' Bulletin, therefore, the report has both practical and scientific merit, and I recommend that it be published especially for the information of the farmers' wives.

Respectfully,

H. W. WILEY,
Chief, Bureau of Chemistry.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction........ 5
The science of sterilization........ 5
Exclusion of the air........ 7
So-called "preserving powders"........ 8
Kinds of jars........ 8
Containers for sterilizing........ 10
Selection and preparation of vegetables........ 10
  Corn........ 11
  String beans........ 12
  Eggplant........ 13
  Beets........ 13
  Okra or gumbo........ 13
  Summer squash........ 13
  English peas........ 13
  Asparagus........ 14
  Cauliflower........ 14
  Carrots and parsnips........ 14
  Tomatoes........ 14
  Kohl-rabi........ 14
  Lima beans........ 14
  Pumpkin or winter squash........ 15
  Succotash........ 15
  Vegetable roast........ 15
Freshness of flavor and color........ 15
How to open a jar........ 16
Cautions........ 16

ILLUSTRATIONS.

Page.

FIG. 1. Ordinary screw-top jar 8

2. Improved screw-top jar 9

3. Jar with metal lacquered top 9

4. Spring-top jar 10

5. Sterilizer, showing false bottom 10

6. Steam cooker 11

7. Position of spring during sterilizing 11

8. Position of spring after sterilizing 12

9. Manner of testing 12

CANNING VEGETABLES IN THE HOME.

INTRODUCTION.

One of the many problems that confront the American housewife is the supply of vegetables for her table during the winter months. "What can I have for dinner to-day?" is a question often heard. Since the advent of the modern greenhouse and the forcing of vegetables under glass, fresh vegetables can usually be found at any time in the markets of the large cities. But the cost of forcing vegetables or growing them out of season is and will continue to be very great. This makes the price so high as almost to prohibit their use by people of moderate means, except as a luxury. A healthful diet, however, must include vegetables, and therefore the housewife turns to canned goods as the only alternative. These are sometimes poor substitutes for the fresh article, especially the cheaper commercial grades, which necessarily lack the delicate flavor of the fresh vegetable. There is practically no danger, however, from contamination with tin or other metals providing the containers are made of proper materials and handled carefully. In some cases the proper care is not taken in packing vegetables for market. The decayed and refuse portions are not so carefully removed as they should be and the requisite degree of cleanliness is not observed in their packing. Happily, however, such carelessness is not general.

Every housewife may run a miniature canning factory in her own kitchen, and on the farm this is especially economical and desirable, the economy being less pronounced in the case of city dwellers, who must buy their fruits and vegetables. Enough vegetables annually go to waste from the average farm garden to supply the table during the entire winter. But usually the farmer's wife cans her tomatoes, preserves her fruits, and leaves her most wholesome and nutritious vegetables to decay in the field, under the impression that it is impossible to keep them. This is a great mistake. It is just as easy to keep corn or string beans as it is to keep tomatoes, if you know how.

THE SCIENCE OF STERILIZATION.

The art of canning or preserving in one form or another is almost as old as history itself. The early Chinese possessed this secret long before the era of modern civilization, but "the reasons why" which lay back of the art have only recently been thoroughly explained.

The great secret of canning or preserving lies in complete sterilization. The air we breathe, the water we drink, all fruits and vegetables, are teeming with minute forms of life which we call bacteria, or molds, or germs. These germs are practically the sole cause of decomposition or rotting. The exclusion of air from canned articles, which was formerly supposed to be so important, is unnecessary provided the air is sterile or free from germs. The exclusion of air is necessary only because in excluding it we exclude the germ. In other words, air which has been sterilized or freed from germs by heat or mechanical means can be passed continuously over canned articles without affecting them in the least. If a glass bottle is filled with some vegetable which ordinarily spoils very rapidly—for instance, string beans—and, instead of a cork, it is stoppered with a thick plug of raw cotton and heated until all germ life is destroyed, the beans will keep indefinitely. The air can readily pass in and out of the bottle through the plug of cotton, while the germs from the outside air can not pass through, but are caught and held in its meshes. This shows that the germs and their spores or seeds are the only causes of spoilage that we have to deal with in canning.

Germs which cause decay may be divided into three classes—yeasts, molds, and bacteria. All three of these are themselves plants of a very low order, and all attack other plants of a higher order in somewhat the same way. Every housewife is familiar with the yeast plant and its habits. It thrives in substances containing sugar, which it decomposes or breaks up into carbonic acid and alcohol. This fact is made use of in bread making, as well as in the manufacture of distilled spirits. Yeasts are easily killed, so they can be left out of consideration in canning vegetables. Molds, like yeasts, thrive in mixtures containing sugar, as well as in acid vegetables, such as the tomato, where neither yeasts nor bacteria readily grow. Although more resistant to heat than yeasts, they are usually killed at the temperature of boiling water. As a general rule, molds are likely to attack jellies and preserves and are not concerned with the spoiling of canned vegetables. The spoiling of vegetables is due primarily to bacteria.

Bacteria are also much more resistant to heat than yeasts. They thrive in products like milk and in meats and vegetables rich in protein, such as peas, beans, etc. All known species of molds require air in which to work. This is not true of bacteria, certain species of which will live and cause vegetables to decompose even when no air is present. When these particular species are present the exclusion of air is no safeguard against decay, unless the vegetable is first thoroughly sterilized. Bacteria are so small that they can only be seen with a microscope, and they reproduce themselves with amazing rapidity. One bacterium under favorable conditions will produce about twenty millions in the course of twenty-four hours. Accordingly certain vegetables spoil more rapidly than others, because they furnish a better medium for bacterial growth.

The reproduction of bacteria is brought about by one of two processes. The germ either divides itself into two parts, making two bacteria where one existed before, or else reproduces itself by means of spores. These spores may be compared with seeds of an ordinary plant, and they present the chief difficulty in canning vegetables. While the parent bacteria may be readily killed at the temperature of boiling water, the seeds retain their vitality for a long time even at that temperature, and upon cooling will germinate, and the newly formed bacteria will begin their destructive work. Therefore it is necessary, in order to completely sterilize a vegetable, to heat it to the boiling point of water and keep it at that temperature for about one hour, upon two or three successive days, or else keep it at the temperature of boiling water for a long period of time—about five hours. The process of boiling upon successive days is the one that is always employed in scientific work and is much to be preferred. The boiling on the first day kills all the molds and practically all of the bacteria, but does not kill the spores or seeds.

As soon as the jar cools these seeds germinate and a fresh crop of bacteria begin work upon the vegetables. The boiling upon the second day kills this crop of bacteria before they have had time to develop spores. The boiling upon the third day is not always necessary, but is advisable in order to be sure that the sterilization is complete. Among scientists this is called fractional sterilization, and this principle constitutes the whole secret of canning. If the housewife will only bear this in mind she will be able with a little ingenuity to can any meat, fruit, or vegetable.

EXCLUSION OF THE AIR.

Even after sterilization is complete the work is not yet done. The spores of bacteria are so light that they float about in the air and settle upon almost everything. The air is alive with them. A bubble of air no larger than a pea may contain hundreds of them. Therefore it is necessary after sterilizing a jar of vegetables to exclude carefully all outside air. If one bacterium or one of its spores should get in and find a resting place, in the course of a few days the contents of the jar would spoil. This is why the exclusion of air is an important factor, not because the air itself does any damage but because of the ever-present bacteria.

All of this may seem new fashioned and unnecessary to some housekeepers. The writer has often heard it said: "My grandmother never did this, and she was the most successful woman at canning that I ever knew." Possibly so, but it must be remembered that grandmother made her preserves—delicious they were, too—and canned her tomatoes, but did not attempt to keep the most nutritious and most delicately flavored vegetables, such as lima beans, string beans, okra, asparagus, or even corn.

SO-CALLED "PRESERVING POWDERS."

There are a great many brands of so-called "preserving powders" on the market. These are sold not only under advertised trade names but by druggists and peddlers everywhere. In the directions for use the housewife is told to fill the jar with the fruit or vegetable to be canned, to cover with water, and to add a teaspoonful of the powder. It is true that these powders may prevent the decay of the fruit or vegetable, but they also encourage uncleanly, careless work, and in the hands of inexperienced persons may be dangerous. While with small doses the influence may not be apparent in an adult in normal health, with a child or an invalid the effect may be of a serious nature. The proper way to sterilize is by means of heat, and as this can be done very easily and cheaply the use of chemical preservatives in canning is not to be recommended.

KINDS OF JARS.

The first requisite for successful canning is a good jar. Glass is the most satisfactory. Tin is more or less soluble in the juices of fruits and vegetables. Even the most improved styles of tin cans which are lacquered on the inside to prevent the juice from coming in contact with the tin are open to this objection. While the amount of tin dissolved under these conditions is very small, enough does come through the lacquer and into the contents of the can to be detected in an ordinary analysis. While the small amount of tin may not be injurious, it gives an undesirable color to many canned articles. Tin cans can not readily be used a second time, while glass with proper care will last indefinitely.

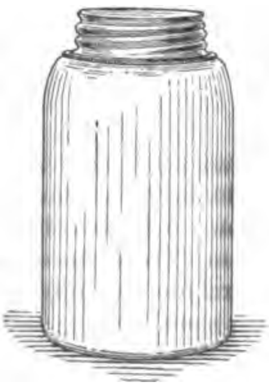

FIG. 1.—Ordinary screw-top jar.

There are a great many kinds of glass jars on the market, many of them possessing certain distinct points of advantage. The ordinary screw-top jar is the one in most common use (fig. 1). Although cheap in price, these jars are the most expensive in the long run. The tops last only a few years and, being cheaply made, the breakage is usually greater than that of a better grade of jar. The tops also furnish an excellent hiding place for germs, which makes sterilization very difficult. An improved type of screw-top jar is shown in fig. 2. These are fitted with a glass top held in place by a metal cover which screws down over the neck of the jar. If the canning or sterilization is conducted properly, practically all of the air will be driven out of the jar by the steam. Upon cooling, this is condensed, a vacuum is formed on the inside which clamps down the glass top against the rubber ring and seals the jar automatically. The metal cover can then be removed, as the pressure of the outside air will hold the glass top securely in place.

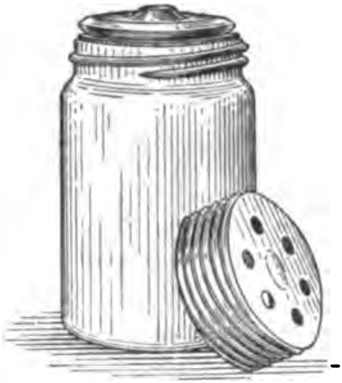
FIG. 2.—Improved screw-top jar.

Another type of jar in common use is shown in fig. 3. These require no rubber rings, but are fitted with a metal top, lacquered on both sides and having a groove around the lower edge. This groove contains a composition of the consistency of rubber which is melted during canning by the heat of the jar and forms a seal that takes the place of the rubber ring. These metal tops must be renewed each year, as it is necessary to puncture them in order to open the jar.

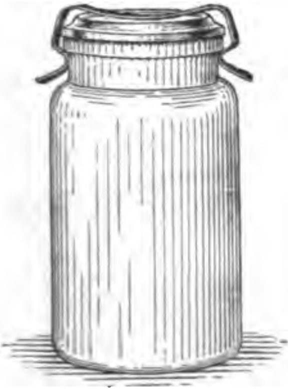
FIG. 3.—Jar with metal lacquered top.

The most satisfactory jar that the writer has had any experience with is the one shown in figs. 4, 7, 8, and 9. This has a rubber ring and glass top which is held in place by a simple wire spring. There are several brands of these jars on the market, so no difficulty should be experienced in obtaining them. Vegetables often spoil after being sterilized because of defective rubbers. It is poor economy to buy cheap rubbers or to use them a second time. As a general rule black rubbers are more durable than white ones.

Buy a good grade of jar. The best quality usually retails at from a dollar to a dollar and twenty-five cents a dozen. The initial expense may be, therefore, somewhat high, but with proper care they should last many years. The annual breakage should be less than 3 per cent on the average. In selecting a jar always give preference to those having wide mouths. In canning whole fruit or vegetables and in cleaning the jars the wide mouth will be found to be decidedly preferable.

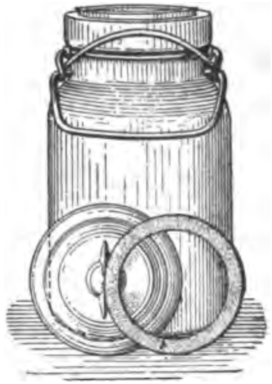

FIG. 4.—Spring-top jar.

CONTAINERS FOR STERILIZING.

The writer uses a tin clothes boiler with a false bottom made of wire netting cut to fit it (fig. 5). The netting is made of medium-sized galvanized wire (No. 16) with one-half inch mesh. A false bottom is absolutely necessary, as the jars will break if set flat upon the bottom of the boiler. Narrow strips of wood, straw, or almost anything of this nature may be used for the purpose, but the wire gauze is clean and convenient.

There are several varieties of patent steamers or steam cookers in common use. These have either one or two doors and hold a dozen or more quart jars (fig. 6). They are ideal for canning, but they are somewhat expensive and can be easily dispensed with. A common ham boiler or clothes boiler with a tight-fitting cover will answer every purpose.

SELECTION AND PREPARATION OF VEGETABLES.

The first step in successful canning is the selection and preparation of the vegetables. Never attempt to can any vegetable that has matured and commenced to harden or one that has begun to decay. As a general rule, young vegetables are superior in flavor and texture to the more mature ones. This is especially true of string beans, okra, and asparagus. Vegetables are better if gathered in the early morning while the dew is still on them. If it is impossible to can them immediately, do not allow them to wither, but put them in cold water or in a cold, damp place and keep them crisp until you are ready for them. Do your canning in a well-swept and well-dusted room. This will tend to reduce the number of spores floating about and lessen the chances of inoculation.

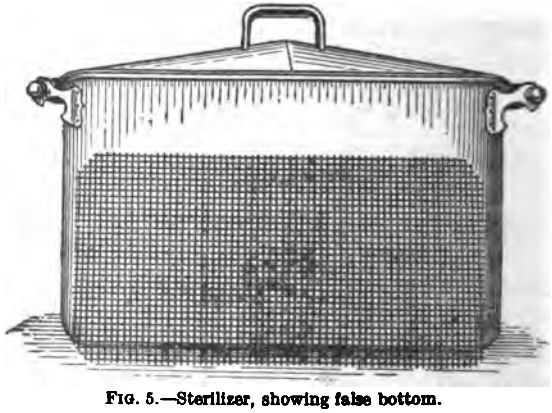

FIG. 5.—Sterilizer, showing false bottom.

In the following pages are given directions for canning some of the more common vegetables, but the housewife can add to these at will. The principle of sterilization is the same for all meats, fruits, and vegetables.

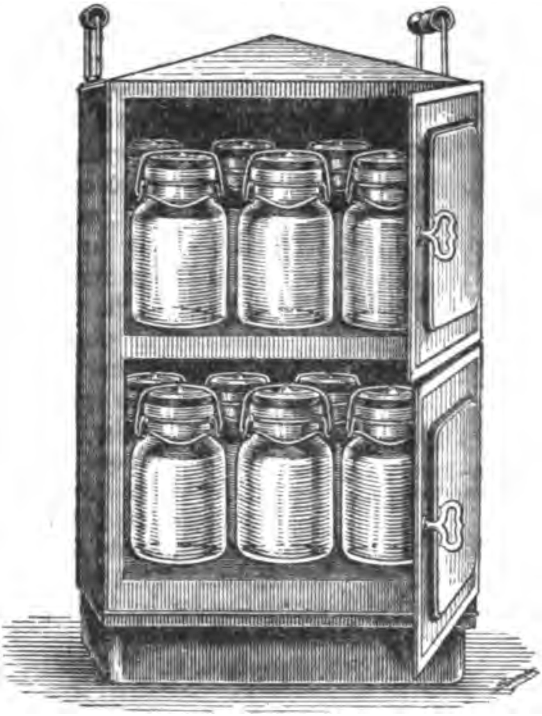

FIG. 6.—Steam cooker.

CORN.

Contrary to the general opinion, corn is one of the easiest vegetables to can. The United States Department of Agriculture has shown that the amount of sugar in the sweet varieties diminishes very rapidly after the ear is pulled from the stalk; therefore in order to retain the original sweetness and flavor it is necessary to can corn very soon after it is pulled—within an hour if possible. Select the ears with full grains before they have begun to harden, as this is the period of greatest sugar content. Husk them and brush the silks off with a stiff brush. Shear off the grains with a sharp knife and pack the jar full. Add salt to taste, usually about a teaspoonful to the quart is sufficient, and fill up the jar to the top with cold water. Put the rubber ring around the neck of the jar and place the glass top on loosely, as shown in fig. 7. Be careful not to press down the spring at the side of the jar.

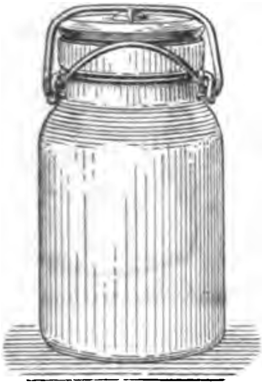

FIG. 7.—Position of spring during sterilizing.

Place the false bottom in the boiler and put in as many jars as the boiler will conveniently hold. Don't try to crowd them in. Leave space between them. Pour in about 3 inches of cold water, or just enough to form steam and to prevent the boiler from going dry during the boiling. It is not necessary to have the water up to the neck of the jars, as the steam will do the cooking. Put the cover on the boiler and set it on the stove. Bring the water to a boil and keep it boiling for one hour. At the end of that time remove the cover of the boiler and allow the steam to escape. Press down the spring at the side of the jar, as shown in fig. 8. This clamps on the top and will prevent any outside air from entering. The jars can now be removed and cooled or allowed to stand in the boiler until the next day.

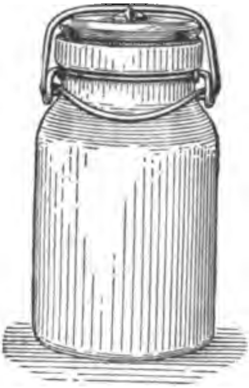
FIG. 8.—Position of spring after sterilizing.

On the second day raise the spring at the side of the jar, as shown in fig. 7. This will relieve any pressure from steam that might accumulate inside the jar during the second cooking. Place the jars again in the boiler and boil for one hour. Clamp on the top as on the preceding day and allow them to cool. Repeat this operation on the third day. In removing the jars from the boiler be careful not to expose them to a draft of cold air while they are hot, as a sudden change in temperature is likely to crack them.

After the sterilization is complete the jars may be set aside for a day or two and then tested. This is done by releasing the spring at the side and picking up the jar by the top (fig. 9). If there has been the least bit of decomposition, or if sterilization has not been complete, the top will come off. This is because the pressure on the top has been relieved by the gas formed by the bacteria. In this case it is always best to empty out the corn and fill up the jar with a fresh supply. If canning fruits or some expensive vegetable, however, examine the contents of the jar and, if the decomposition has not gone far enough to injure the flavor, place it once more in the boiler and sterilize over again. If the top does not come off, one may be reasonably sure that the corn is keeping. Corn is often subject to the attack of anaerobic bacteria. The spores of these are sometimes very hard to kill and remain alive even after boiling for one hour. In case any jars spoil, increase the time of boiling to an hour and a half.

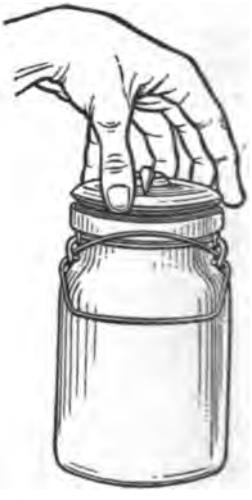
FIG. 9.—Manner of testing.

STRING BEANS.

Select young and tender beans, string them, and break them into short lengths. Pack firmly in the jar, cover with cold water, and add a teaspoon of salt to each quart. Put on the rubber and top and boil for one hour on each of three successive days, as directed under "Corn." A small pod of red pepper placed in the bottom of the jar will give a delightful flavor to this vegetable.

EGGPLANT.

Pare the eggplant, cut in thin slices, and drop in boiling water for fifteen or twenty minutes. Drain off the water and pack the slices in the jar. Cover with water and sterilize as directed under "Corn." The slices of eggplant are pliable and may be taken from the jar without being broken and either fried in bread crumbs or made into pudding and baked.

BEETS.

Although beets will keep in the cellar over winter, it is very desirable to can them while they are young and tender, as the mature beet is apt to be stringy and lacking in flavor. Wash the young beets, cut off the tops, and put them in boiling water for about an hour and a half, or until they are thoroughly cooked. Take off the skins, cut in thin slices, and pack into the jars. Cover with water and sterilize in the manner previously described. If a mild pickle is desired, make a mixture of equal parts of water and good vinegar, sweeten to taste, and cover the beets with this mixture instead of water.

OKRA OR GUMBO.

This is a vegetable worthy of more extended culture. Although extensively grown in the South, it is comparatively unknown in the North. It is easily kept and makes a delicious vegetable for the winter. Wash the young and tender pods, cut them in short lengths, pack in the jars, cover with water, and sterilize. Okra is used for soups or stews.

SUMMER SQUASH.

Cut the vegetable into small blocks, pack in the jars, and cover with water. Add a teaspoon of salt to each quart and sterilize. It is sometimes preferable with this vegetable, however, to pare off the skin, boil or steam until thoroughly done, mash them, and then pack in the jars and sterilize. If canned in the latter way, it is advisable to steam them for an hour and a half, instead of for an hour, on each of three days, as the heat penetrates the jar very slowly. It is absolutely necessary that the interior of the jar should reach the temperature of boiling water. A jar will usually hold about twice as much of the cooked vegetable as it will of the uncooked.

ENGLISH PEAS.

When prepared and canned in the proper way, peas are easily kept and never lose the delicate flavor that they possess when fresh. Shell the young peas, pack in jars, and sterilize as directed under "Corn."

ASPARAGUS.

Can the young tips only, in the same way as you would corn.

CAULIFLOWER.

This vegetable usually keeps very well, but if the supply for the winter should begin to spoil it may be necessary to can it during the summer. Prepare it as you would for the table, pack it into jars, and sterilize.

CARROTS AND PARSNIPS.

These, if gathered during the early summer and canned, make most excellent vegetables for the winter. The young plants at that season are not stringy and have not yet developed the strong taste that is so objectionable to some people. Prepare as you would for the table, and sterilize.

TOMATOES.

Every housewife knows how to can tomatoes. They are very easily kept, even in the common screw-top jar. If one already has on hand a number of jars of this pattern, it is best to use them for preserves or for canning tomatoes and to purchase the more modern styles for canning other vegetables. In using the screw-top jars be careful to sterilize them first by placing in cold water, bringing to a boil, and boiling for about ten minutes. The rubber and top should also be immersed in boiling water for the same length of time. Remove them from the boiling water when needed, handling as little as possible. Be careful not to put the fingers on the inside of the top or the inner edge of the rubber. Fill the jar with the cooked tomatoes while steaming hot, put on the rubber, screw on the top firmly, invert it, and let it stand in that position until cool.

KOHL-RABI.

This vegetable resembles the turnip in its habits of growth, although in flavor it more nearly approaches the cauliflower. It is grown in many sections of the North, but in the South it is almost unknown. Prepare it as you would turnips, pack in the jar, and sterilize.

LIMA BEANS.

Lima beans lose their flavor very quickly after being shelled; therefore it is necessary to can them as soon as possible after gathering. Discard all pods that have begun to harden, and proceed as you would with corn.

PUMPKIN OR WINTER SQUASH.

If provided with a warm, dry cellar, one may keep certain varieties of these vegetables all winter. Some of the best varieties, however, do not keep well, and even the best keepers when not properly housed begin to decay in December or January. It is then necessary to can them in order to save them. If one has a limited number of jars, it is a good plan to fill them all with other vegetables during the summer and upon the approach of frost to gather the pumpkins and bring them indoors. By the time the pumpkins begin to spoil, enough jars will be emptied to hold them. They can now be steamed and canned in the same way as summer squash. In this way a supply of jars may be made to do double service.

SUCCOTASH.

The writer has found that a mixture of corn and lima beans, or succotash, is one of the most difficult things to keep. This furnishes one of the very best mediums for bacterial growth; so extreme care must be taken in the process of canning. It is advisable to gather the corn and beans early in the morning and prepare and sterilize them in the manner already described. As with summer squash, it is best to boil for an hour and a half, instead of for an hour.

VEGETABLE ROAST.

A rather unusual dish for the winter may be made by canning a mixture of vegetables. Prepare corn, lima beans, tomatoes, string beans, okra, squash, and eggplant as you would for canning separately. Mix these in varying proportions, letting the corn and lima beans predominate. Add two or three medium-sized onions to each quart of this mixture and run all through a food chopper in order to mix it thoroughly. Pack into jars and sterilize. In preparing for the table mix with an equal volume of bread crumbs, a piece of butter the size of a walnut, and one egg; season to taste with pepper and salt, and bake in a round baking dish until brown. Cut into slices as you would a cake and serve hot with a drawn butter sauce.

Corn, okra, and tomatoes, mixed in equal proportions, may be canned in this way as a soup stock.

FRESHNESS OF FLAVOR AND COLOR.

Vegetables when canned properly should retain their attractive color and lose very little of their flavor. It will be found almost impossible to detect any difference either in taste or in appearance between the canned and the fresh article if these directions are carefully followed. The volatile oils which give flavor to most vegetables are not lost during this process of sterilization. Cooking for *three* *short periods* in a *closed* container at a comparatively low temperature instead of cooking for one short period at a high temperature or for *one long period* in an *open* vessel makes the vital difference and insures freshness of flavor and color. After the jars have been sterilized and tested, they should be kept in the dark, as the sunlight will soon destroy the color of the vegetable.

HOW TO OPEN A JAR.

Jars of vegetables are sometimes hard to open, unless it is done in just the right way. Run a thin knife blade under the rubber, next to the jar, and press against it firmly. This will usually let in enough air to release the pressure on the top. In case it does not, place the jar in a deep saucepan of cold water, bring to a boil, and keep it boiling for a few minutes. The jar will then open easily.

CAUTIONS.

These directions for canning apply only to pint and quart jars. If half-gallon jars are used, always increase the time of boiling, making it an hour and a half instead of one hour.

Do not go into canning too deeply at first. Experiment with a few jars in the early part of the season and see if they keep well. It is not a difficult matter to can vegetables properly. The writer has never lost a can of string beans, okra, eggplant, carrots, parsnips, lima beans, beets, asparagus, or pumpkin in several years' experience, and has had only one can of peas spoil, a few cans of corn during the earlier trials, and a few cans of succotash. Any housewife can do equally well. If you follow the directions here given carefully, you will have no difficulty whatever. If you should happen to fail in the first trial, rest assured that you have done something wrong or left something undone. No housewife who has on hand during the winter a supply of home-canned vegetables ready to serve on ten minutes' notice will ever regret the trouble or difficulties experienced in learning.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 360.

Experiment Station Work,

LI.

Compiled from the Publications of the Agricultural Experiment Stations.

DISTANCE BETWEEN CORN HILLS.
THE BURSTING OF CARNATIONS.
STREET TREES.
SPRAYING FOR WEEDS.
MARKET CLASSES AND GRADES OF SHEEP.
VETCH HAY AND VETCH SILAGE FOR COWS.
DIGESTIBILITY OF KALE.
HULLED CORN.
MIXING FAT INTO DOUGH.

MARCH, 1909.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS
A. C. TRUE, Director.

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GOVERNMENT PRINTING OFFICE.
1909.

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EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

CONTENTS OF NO. LI.

Page.

Distance between corn hills ---- 5
The bursting of carnations ---- 7
Street trees ---- 9
Spraying for weeds ---- 15
Market classes and grades of sheep ---- 17
  Mutton sheep ---- 18
  Bucks and stags ---- 24
  Feeder sheep ---- 24
  Breeding sheep ---- 27
  Miscellaneous ---- 27
Vetch hay and vetch silage as feeds for cows ---- 29
Digestibility of kale ---- 30
Hulled corn ---- 31
Methods of mixing fat into dough ---- 32

ILLUSTRATIONS.

Page.

Fig. 1. The correct method of attaching a guy wire 9

2. "Well" around trees 10

3. Preservation by means of cement filling 11

4. Staking and protecting newly planted trees 12

5. A grating to cover "well" 13

6. Bridge grafting, for the preservation of girdled trees 14

360

EXPERIMENT STATION WORK.[a]

DISTANCE BETWEEN CORN HILLS.[b]

The distance at which corn is planted in check rows has been decreased by several inches since the first machine planters were put upon the market. It has evidently been the opinion of farmers, and agricultural implement manufacturers as well, that the distances formerly used allowed more space than necessary to each hill, and that the number of hills per acre was smaller than could be produced to the best advantage. Distance experiments with corn by the experiment stations and others have been numerous and the results have varied. This would seem to indicate that distance between rows is influenced by different factors, such as soil, season, locality, variety, and that, therefore, no certain distance can be universally the best. Further light has been thrown on this subject by a series of tests conducted from 1903 to 1907 by the Illinois Experiment Station in different sections and on different soils in Illinois. The purpose of this work was to determine the distance at which check rows of corn returned the highest and most profitable yields, and whether planting two kernels per hill at closer distances is better than three kernels at greater distances.

The thickness of planting was varied by increasing or decreasing the distance between rows in both directions. The hills were checked on different plats at distances ranging from 33 to 44 inches, the intermediate distances being 39.6 and 36 inches. The different series were repeated many times each year, in order to equalize differences of soil and season and to make the averages more nearly true. Variations in stand were eliminated so that all parts in the same series were comparable with each other. Attention is called to the fact that with a stand of 100 per cent, hills checked 44 inches apart with two kernels per hill, an acre produces 6,480 stalks; checked 39.6 inches apart, 8,000 stalks; 36 inches apart, 9,680 stalks; and 33 inches apart, 11,520 stalks. If three kernels instead of two are planted per hill, the number of stalks per acre for the different distances is 9,720, 12,000, 14,520, and 17,280, respectively.

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Illinois Sta. Bul. 126.

The average results secured in northern Illinois showed that generally on the two-kernel, as well as on the three-kernel, plats, the average yields increased toward the thicker plantings. On the two-kernel plats the average yields for 1904 to 1907, inclusive, increased from 44.1 bushels per acre for the 44 by 44 inches, or widest planting, to 54.3 bushels for the second thickest, or 33 by 36 inch planting, while where three kernels were planted per hill the widest planting produced on an average 54.1 bushels, which increased as the distance was narrowed down to 61 bushels per acre for the closest, or 33 by 33 inch planting. In central Illinois, just as in the experiments carried on in the northern part of the State, the plats planted with two kernels per hill increased in average yield from the widest planting to the second thickest, the yields being 47.7 bushels and 55 bushels per acre, respectively. The plats with three kernels in the hill ranged in average yield per acre from 46.8 bushels for the closest planting to 52.3 bushels for the 39.6 by 39.6 inch and the 36 by 44 inch distances. The plats planted 36 by 36 inches with two kernels per hill yielded 2.2 bushels per acre more than the plats planted 39.6 by 39.6 inches with three kernels per hill.

The yields in these distance experiments were regrouped to determine whether the distance of planting giving the highest yield on land producing more than 50 bushels will also give the highest yield on land producing less than 50 bushels per acre. The data from the northern fields show that the best yields were taken from the plats with three kernels per hill, and also from those on which the hills were practically 36 inches apart each way. In the central part of the State the highest average yield from land producing over 50 bushels per acre was secured by planting two kernels per hill at a distance of 33 by 36 inches. Almost the same yield was obtained where the hills were planted 39.6 inches apart each way with three kernels per hill. On land yielding less than 50 bushels per acre practically the highest average yield was secured where two kernels were planted per hill in rows 36 inches apart in each direction.

In summarizing the results it is advised that on all ordinary corn-belt land of the northern part of Illinois the hills be planted not more than 36 inches apart and with at least three kernels per hill, and that in central Illinois, on the common brown silt loam prairie lands, sufficiently productive to produce over 50 bushels per acre, corn be checked 39.6 inches apart and three kernels planted per hill, while on the common prairie land not generally producing 50 bushels per acre, as, for instance, average corn-belt land, the hills should be 36 inches apart and only two kernels planted per hill.

THE BURSTING OF CARNATIONS.[a]

Carnation growers are familiar with the often serious tendency of the blooms to split the calyx, or burst, as the trouble is commonly called. The immediate cause of bursting appears to be a too rapid or premature petal development before the bud as a whole has made its growth. It is very prevalent in some varieties. F. Dorner, sr.,[b] says: "There are numerous varieties which habitually split the calyx and are worthless. There are also some which under certain circumstances split what appears to be the strongest kind of a calyx, while, on the other hand, some large flowers are held intact by an apparently weak one." It goes without saying that worthless varieties should be abandoned. Growers have learned from experience, however, that unfavorable cultural conditions may cause serious cases of bursting among varieties which are profitable bloomers when properly grown.

Although there are well-established methods for the general culture of greenhouse carnations, certain varieties differ sufficiently in their requirements to call for specific treatment in some form or other. Such specific treatment must be determined from cultural experience. On the other hand, the fragmentary literature on the subject of bursting would seem to warrant the general statement that plants which have been hardened off or grown slowly, whether through a low temperature, dry soil conditions, or a lack of fertilizer, are very apt to produce bursted blooms when suddenly overstimulated either by too much heat, moisture, or plant food, or through some unfavorable combination of these conditions.

The Maryland Station reports an investigation along this line, in which it appears that a location unfavorable for uniform temperature and moisture conditions will aggravate the bursting tendency. Such a location is found in the rear part of a side bench, when there is no space between the bench and the wall.

> It was noticed that the row of carnations located near the glass of the side benches produced more bursted flowers than did the other rows on the benches. During the winters of 1904–5 and 1905–6, a record was kept of the good flowers and the bursted flowers on the different rows. * * * The row nearest the glass produced 21 per cent of bursted flowers, while only one other row gave as high as 7 per cent.
>
> * * * It was found almost impossible to secure uniform conditions near the glass, the soil drying out badly, although receiving a normal supply of water. Many growers find less trouble with this bursting of the calyx when the benches are so placed as to allow a walk between them and the side walls.

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[a] Compiled from Maryland Sta. Bul. 127; Rhode Island Sta. Bul. 128.

[b] Amer. Breeders' Assoc. Proc., 3 (1907), pp. 67–71.

The walk next to the wall provides for free air circulation around the bench, thus lessening the danger of excessive sun heat and, in some cases, of excessive bottom heat as well. Side ventilators can be used with greater safety and the bench will be given closer inspection.

The Rhode Island Station recently reported an experiment in which the principal object was to determine what influence, if any, nitrogen has upon the tendency of the calyx to split open. Three varieties were used in the work in order to determine whether the same results would be secured regardless of varietal tendencies. The varieties were Hector, Wm. Scott, and Lizzie McGowan. "A long, narrow bench was divided into two equal beds, each 26 inches wide by 8 feet 9 inches long. Like amounts of subsoil were then placed in each. * * * The manurial treatment was identical, excepting that on the east plat no nitrogen was applied, while on the west plat nitrogen in a nitrate, an ammonium salt, and inorganic matter was applied." The experiment was carried on for two years.

> With nitrogen in the manures a great advantage resulted with the variety Hector, both in salable blossoms and the number of those with a perfect calyx.
>
> With the variety Lizzie McGowan, the results were in favor of the use of the nitrogen, especially the first year of the trial, but were far less marked than with the Hector.
>
> In the case of the variety Wm. Scott, the results were better where nitrogen was omitted than where it was employed.
>
> The results show that when the house is maintained at the same temperature, generous manuring with nitrogen may increase the total number of perfect blossoms of one variety of carnations and lessen the number of another variety.
>
> Whether the same differences, as a result of the manuring, would appear if the most favorable temperature for each variety were maintained in the house is yet to be determined.
>
> It appears probable that the character of the manures, as well as the degree of forcing, tends to affect the splitting of the calyx.

C. W. Ward,[a] in the following words, points out how the carnation breeder may lessen the bursting tendency: "In selecting a seedling for the second year's trial, be sure of a firm, large, well-formed calyx, for if you fail to select good firm calyces a crop of 'bursters' may be your reward."

The commercial grower likewise can reduce the trouble by studying the habits and requirements of the individual variety, and by so regulating the various conditions in the greenhouse as to prevent sudden fluctuations in the rate of growth. Although it is doubtful whether the bursting of the blooms can be entirely eliminated, further investigations along this line may lead to methods of control which will reduce the trouble to a minimum.

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[a] The American Carnation: How to Grow It, C. W. Ward, p. 204.

STREET TREES; CARE AND PRESERVATION.[a]

The increasing number of State and municipal laws which are being enacted for the care and preservation of street trees is ample evidence of a growing public interest in this matter. It should be borne in mind, however, that the shade-tree laws of any community can not be thoroughly effective unless the public is familiarized with these laws as well as with the important sources of injury to trees. Adjacent property owners in particular should be equipped with this knowledge, since prompt action on their part will often prevent forms of mistreatment or injury which may temporarily escape the notice of the tree warden.

The sources of injury to street trees are undoubtedly more numerous in the cities and large towns than along village streets and country roads. Nevertheless, the increasing number of overhead electric wires in the latter thoroughfares is resulting in much serious damage. This source of injury and also the effect of illuminating gas escaping into the soil has been discussed in previous bulletins of this series.[b]

In a recent bulletin of the New York Cornell Station, A. D. Taylor discusses many ways in which trees are injured through ignorance and neglect; as, for example, in the course of construction work, by piling building materials against them, in moving buildings, in attaching guy wires, and in grading streets.

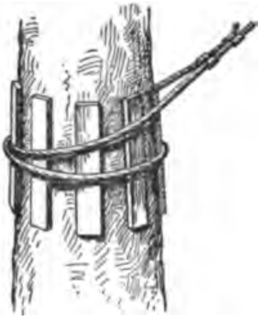
FIG. 1.—The correct method of attaching a guy wire.

The piling of brick, lumber, and stone slabs close against the trunk may cause injuries which allow decay to enter at that point. Tying guy wires for the purpose of supporting derricks or telephone poles is a common practice, and will cause no injury to the tree if properly done. It is done so often without protecting the tree, however, that serious injury results. The correct method of attaching a wire of this kind to a tree is to place a number of small strips of board against the trunk, parallel to its axis, and then bring the pressure of the wires to bear directly on these (see fig. 1). If the trunk is forked the wire may be carried between the branches near the crotch and attached to a crosspiece, which, being placed transversely to the axis of the two branches, brings the pressure to bear on each, and no mechanical injury is caused to the tree. When the pole to be guyed brings little pressure to bear on the wire, a lag screw may be placed in the side of the tree and the guy wires fastened thereto. In any case the growth of the tree may continue without the common danger of its being girdled. * * *

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[a] Compiled from New York Cornell Sta. Bul. 256. See also Massachusetts Sta. Bul. 125.

[b] U. S. Dept. Agr., Farmers' Buls. 210, p. 20; 316, p. 12.

The cutting away of branches in order to make an unobstructed road for the moving of a building along a highway is frequently seen. * * * Adjacent property owners * * * should obtain from the court an injunction, by means of which the work could be delayed until a judgment may be given.

The regrading, widening, and general improvement of highways cause annually the unnecessary loss of many beautiful park and avenue trees. Often, with no intelligent person to direct this part of the work, large numbers of trees are removed which could well have remained. Because a street has been widened, and a valuable tree stands where it may inconvenience traffic a little in the new arrangement, is not sufficient justification for its removal. In such instances, the situation should be carefully investigated and the evidence on both sides considered. The sentiments associated with old landmarks are often too strong to be considered as trifling. The tree to be removed may be so valuable a factor in the æsthetic life of the community that the inconvenience of going around it will never be great enough to warrant its removal.

In regrading lawn areas it sometimes becomes necessary to make deep cuts or large fills about the bases of trees, which would cause their death were they not properly protected. In general, when cuts or fills average between 1 foot and 3 feet in depth, the tree may be preserved by leaving a mound for cuts; or, in the case of fills by building a well around the trunk to keep the soil from the bark (see fig. 2). Trees injured as a result of removing soil from the base die because the roots dry out, while those injured from fills die because the soil packed around the trunk suffocates that part of the tree, kills the small feed roots, and rots the bark. A few of the very hardy species of trees will survive such conditions of fill, while others are very susceptible to its ill effects.

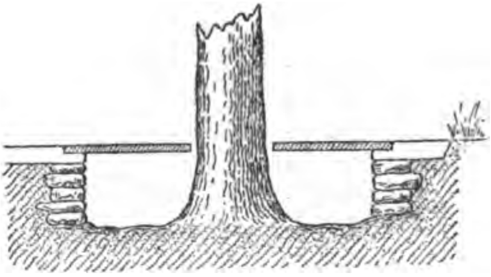

FIG. 2.—" Well " around trees.

Trees with brittle wood, as well as broad-headed, vase-formed trees, are often seriously injured by wind and ice storms. " Protection can be given best only by a correct selection of deciduous trees, and by keeping from conifers the heavy loads of snow, which break the branches during the winter." All dead wood should be removed, both for the sake of appearance and because it is a source of danger to the public.

Trees are often injured, and sometimes killed, from the effects of freezing.

The greatest danger from freezing lies not in the fact that many trees in a normal condition of growth are killed back, but rather that improper pruning and unprotected wounds cause cavities to appear on the trunk and larger branches; these fill with water during the summer months, and during the winter months the ice formed in them splits seams up and down these parts of a tree (see fig. 3). These seams or cracks, small at first, close during the first summer, but during the succeeding winter are again subjected to freezing processes, which open permanent cracks that continue to increase in size from year to year, and to give free access to the many disintegrating processes of nature. The only protection for such a tree is to employ some one who is fully informed on the methods of tree surgery to seal the cavity, and thus prevent further decay or freezing.

In selecting a species for planting in any particular region it is best not to accept the advice of a journeyman nurseryman, but rather to seek some one who is acquainted with the climatic conditions of the region and who knows the degree of hardiness that a species should possess to be grown successfully.

Other sources of injury discussed in the bulletin referred to are horse bites, grazing by wagon wheels, starving of root systems, smoke and gas from factories, overcrowding by improper spacing, and girdling by wire labels. Trees can be readily protected from horses and vehicles by using some sort of guard. One made of wire netting, as illustrated in figure 4, is both neat and effective. There are many good ready-made guards on the market.

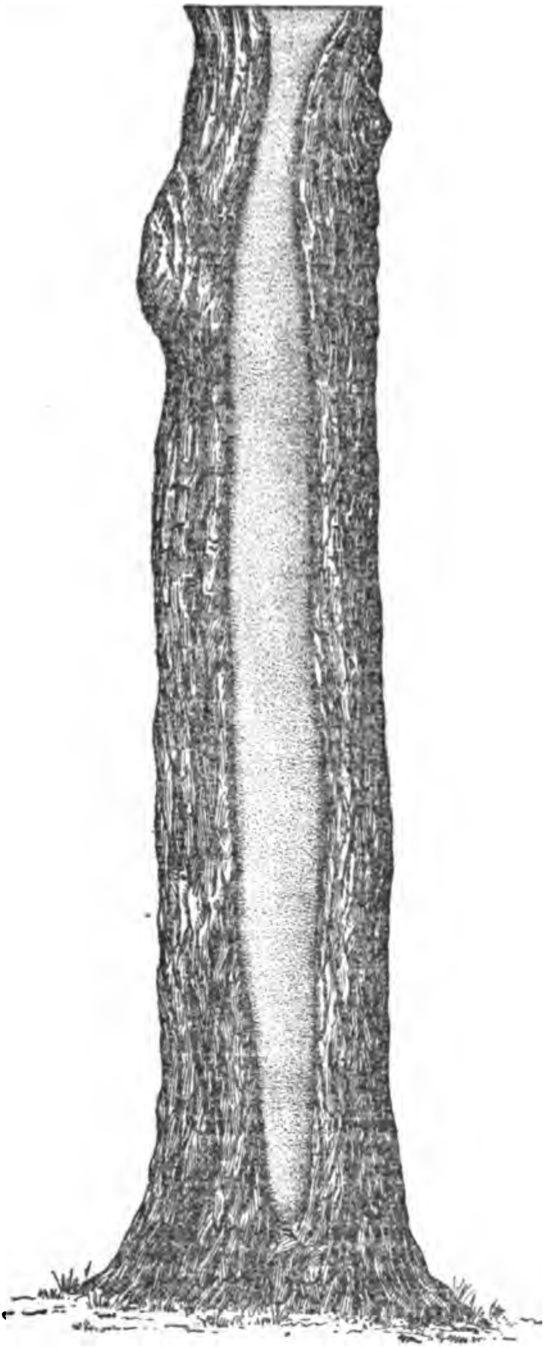

FIG. 3.—Preservation by means of cement filling.

These guards should be removed as soon as the trees attain the size when binding is likely to take place. Such binding is likely to force the upper part of the trunk to grow out over the top of the guard and so lessen the strength of the tree, if not completely to girdle it.

In some cities ordinances provide penalties for the hitching of horses to trees on the highway, and such ordinances should be enforced. * * * Each community must expect a certain amount of accidental injury from this source; but no community should permit the custom to prevail of making a hitching post of a tree standing in front of a residence.

Trees that show injury from the above causes, and especially those that have areas of the trunk devoid of bark, should be given attention without delay, the ragged edges of the bark being cut to a smooth edge and the entire area covered with paint or tar to protect the wood during the process of healing.

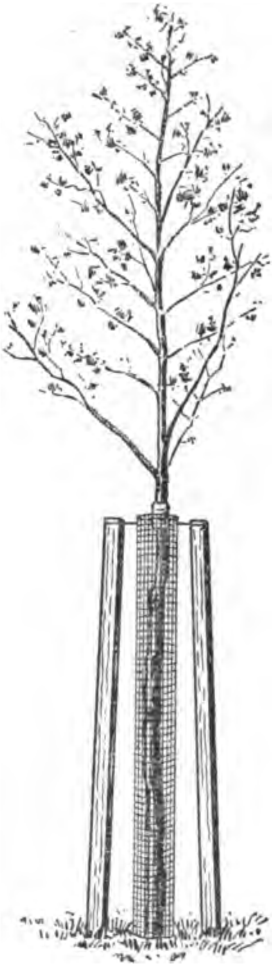

FIG. 4.—Staking and protecting newly planted trees.

The soil along the streets and highways is frequently of a sterile nature. This is particularly true where big fills or deep cuts have been made. In some cases the soils are too wet and in others they are too dry for favorable root development.

The trees on city streets suffer most often because of a naturally poor soil and a lack of sufficient water supply. City streets that are macadamized, paved, or concreted present a surface layer that shuts off almost completely the natural means by which water may reach the roots, and directs all of the surface drainage into catch-basins and sewers. Thus, trees on such streets are subjected to the extreme of adverse conditions, and their natural vitality and soil adaptation must be such that they can withstand the abnormal strain on their vitality or they are certain to meet with an unnatural and premature death. Only a very small percentage of the trees used for city work are of the species best adapted to withstand the conditions.

A scarcity of water from the surface, together with an abundant supply from the subsoil, fosters the production of deep-seated roots, which are one of the most valuable assets of a good shade tree. On the other hand, a thoroughly water-clogged soil admits no air circulation and increases the tendency to the development of surface roots, which are killed during periods of drought; it also provides avenues for root diseases, and finally leads to the death of the tree. Poor soils bring about the condition often known as "stag-head," the symptoms of which are a stunted and sickly appearance of the tree, the presence of slender and weak branches, and a sparsely scattered yellow foliage. The remedy for such a condition depends on its stage of development when detected. In its early stages the tree may be rejuvenated by digging out a quantity of the poor soil and replacing with good loam; if the specimen shows too great a degree of weakness it had better be substitued by a younger, vigorous specimen.

Along city streets, where conditions are so often unfavorable to tree growth, the holes for newly planted trees should be filled with loamy soil, and they should be large enough to provide for future root development. A bed 4 feet wide by 8 feet long and 2 feet deep is none too large. In streets which are often congested with people it may not be feasible to leave such a large open space for each tree. In such cases an iron grating, as shown in figure 5, can be placed over the area that is not paved. This will prevent the soil from becoming impenetrable to surface water.

In large manufacturing centers smoke and atmospheric gases are often present in sufficient quantities to seriously injure or even kill the surrounding trees. "The functions of the leaves are retarded in two ways: First, the breathing pores, or stomata, become choked with the soot; and, second, many gases in themselves may be poisonous, even when diluted with the atmosphere." Since most trees are subject to the effects of smoke and gas, it is highly advisable that "trees should be selected on the basis of results secured with similar species in other cities and towns under similar conditions." Municipal authorities may be able to prevent the excessive production of smoke and gases, but it is very probable that they will always be present in considerable quantities wherever factory interests are large.

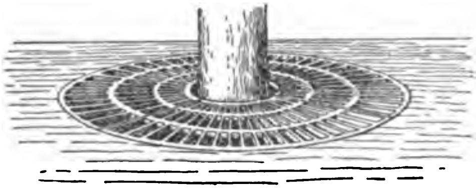
FIG. 5.—A grating to cover "well."

Overcrowding of street trees can be prevented if the trees are properly spaced when planted. Information relative to the space required for the normal development of our shade-tree species is not difficult to obtain. In situations where there are no shade trees, there is a tendency to plant close, in order to secure shade quickly. There is danger in the close planting of young trees, however, due to "the necessity of their removal at a subsequent date, when only a person possessing the courage of his convictions will take out the trees that should be sacrificed. * * * Every town and city possesses trees that are suffering from this evil of overcrowding. Each community should designate some intelligent person to direct the work of caring for the pruning of such trees, who, despite false sentiment, will accomplish the work."

Trees that have been seriously girdled through failure to remove the label wires, or from other causes, can often be saved by bridge-grafting the wounded part. "This is done by trimming smooth the edges of the girdled part and inserting scions of the same species under the bark in such a way that the wound is bridged over (see fig. 6). These scions, being placed very close together around the stem, become united at the ends with the old trunk and serve to conduct the elaborated food material down to the lower parts of the tree. During the period of uniting the scions are covered with grafting wax much as is an ordinary graft, and no shoots developing from buds on the scions are permitted to grow. In time, as the tree develops, the wounded part is entirely healed."

Mr. Taylor calls attention to two forms of tree butchery or improper pruning: "The butchery that is practiced when wires are first strung, and later at intervals to prevent the subsequent growths from coming in contact with the wires," and the butchery by men "who, through ignorance of the fundamental principles which underlie the operations they would perform, and yet with the best of intentions, have ruined whole avenues of valuable trees by the very process which was intended to prolong the lives of these trees and to add to their beauty and usefulness." Such careless or ignorant treatment results in many ugly wounds and projecting stubs of dead branches which, if neglected, may lead to the development of large cavities. Tree owners in general should employ only well-recommended persons to prune their trees and to treat existing wounds. The treatment of such wounds has, in recent years, become known as "tree surgery;"

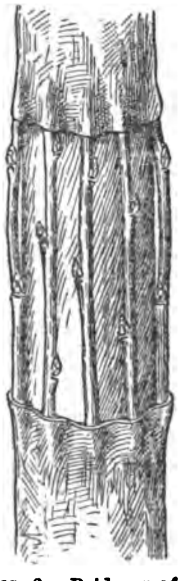

FIG. 6.—Bridge grafting, for the preservation of girdled trees.

Systematic pruning and tree surgery are very closely related. Tree surgery includes the intelligent protection of all mechanical injuries and cavities. Pruning requires a previous intimate knowledge of the habits of growth of trees; surgery, on the other hand, requires, in addition, a knowledge of the best methods for making cavities air-tight and preventing decay. The filling of cavities in trees has not been practiced sufficiently long to warrant making a definite statement as to the permanent success or failure of the operation; the work is still in an experimental stage. The caring for cavities in trees must be urged as the only means of preserving affected specimens, and the preservation of many noble specimens has been at least temporarily assured through the efforts of those practicing this kind of work.

The subject of pruning as well as the protection of wounds and the treatment of hollow trunks is discussed in a previous Farmers' Bulletin[a] and will not be further considered at this time. The reader is also referred to bulletins dealing with insect enemies of trees,[a] tree planting on rural grounds,[b] and beautifying the home grounds.[c]

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[a] U. S. Dept. Agr., Farmers' Bul. 181.

The literature on the subject of shade-tree protection will be of the most value when it serves as a means for preventing rather than curing injuries. By far the greater part of the injuries from which trees suffer can be prevented. When once inflicted, however, it is often very difficult or even impossible to remedy them adequately. In many cases the existing laws are quite sufficient to give all the protection desired. The people should know the laws, and have interest enough in the preservation of trees to insist that they shall be obeyed. The most successful plan for cities and large towns seems to be to place the care of street trees directly in charge of a commission or park board empowered by special ordinances to carry out its plans. This gives opportunity for a systematic development of tree culture throughout the entire community and makes it possible to employ experts to direct the work. Similar arrangements can also be adopted in smaller communities with such changes as are necessary to suit local conditions.

SPRAYING FOR WEEDS.[d]

The eradication of weeds by other than cultural methods has been a subject of study at a number of the agricultural experiment stations and elsewhere. This has resulted in the discovery that various chemicals through their corrosive or other action will destroy many kinds of weeds. As long ago as 1895 it was shown by the Vermont Station that the orange hawkweed, a pest in lawns and pastures, could be controlled by sowing salt over the lawns at the rate of about 3,000 pounds per acre without injury to the grass. Lime, salt, arsenite of soda, gasoline, kerosene, crude carbolic acid, and copper sulphate have all been recommended for destroying weeds in drives, walks, tennis courts, and other places where it is desired to keep down all plant growth. Where cultivated plants are grown, thorough tillage can be relied upon to keep down weeds, but the serious problem of eradicating weeds in grain fields, pastures, and large lawns is the one to which present consideration is given. For this purpose, whatever materials are used they must not be seriously injurious to the grain crop or the grass, yet they must be sufficiently destructive of weeds to make their use economically practicable.

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[a] U. S. Dept. Agr., Farmers' Bul. 99; 296, p. 19.

[b] U. S. Dept. Agr., Farmers' Bul. 134.

[c] U. S. Dept. Agr., Farmers' Bul. 185.

[d] Compiled from Minnesota Sta. Bul. 95; North Dakota Sta. Bul. 80; Rpt. 1907, p. 76; Rhode Island Sta. Rpt. 1906, p. 159; Vermont Sta. Rpt. 1895, p. 115; Wisconsin Sta. Rpt. 1906, p. 259. See also U. S. Dept. Agr., Farmers' Buls. 124, p. 19, and 296, p. 10.

In parts of the grain-producing States of the Northwest, wild mustard, or charlock, and wild radish have become especially troublesome, the wild mustard particularly so. This weed is very common in wheat, oat, flax, and other grain fields from Wisconsin to the Dakotas and adjoining States, and it not only crowds out more valuable plants, but it may become positively injurious through its abundance. Like many others of our most troublesome species, the wild mustard is of European origin, and for many years spraying with corrosive chemicals has been practiced in the warfare against the pest in Europe. Copper sulphate (blue vitriol) and iron sulphate (green vitriol or copperas) are the substances most used. Both are efficient in destroying the wild mustard, the principal difference being in their relative cost. The blue vitriol costs more per pound, but does not require as strong a solution as is necessary of iron sulphate or copperas. There is now on the market a granular form of iron sulphate that can be secured for about $10 or $12 per ton, or even less when bought in large quantities. This is applied in the form of a solution, about 100 pounds of copperas being dissolved in 50 gallons of water. At this rate it makes about a 20 per cent solution, and 50 gallons is sufficient for spraying 1 acre, if properly applied. For its application a good spraying machine is required, and if a considerable area is to be treated one of the better power sprayers that deliver the solution with considerable force should be used. For small areas, hand or knapsack sprayers may be employed.

The directions given by the Wisconsin Station for spraying oat fields with a solution of iron sulphate for the eradication of wild mustard will apply to the treatment of almost any grain or grass field.

> The spraying should be done on a calm, bright day, after the dew has disappeared, as the work is more effective if the solution is put on in the warm sunlight. When rain follows the spraying within a few hours the extermination of the mustard will not be complete.
>
> The grain fields should be sprayed when the mustard plants are in the third leaf, or before the plants are in blossom, in order to have the spray do the most effective work. The day following the spraying the tips of the blades of grain may be somewhat blackened, but no detrimental effects can be noticed, either to the crop or grasses seeded with it, two weeks after spraying.
>
> Daisies, cocklebur, bindweed, ragweed, chicory, sheep sorrel, yellow dock, wild lettuce, and many other weeds were partially or wholly eradicated from the fields where tests were made for the extermination of mustard.

In addition to the charlock, or wild mustard, and those mentioned above, other weeds are destroyed by the spray without injury to the crops, among them, according to the reports from the North Dakota Station, being the very troublesome Canada thistle.

The explanation of the action of the chemicals seems to be about as follows: The chemical, which is corrosive, attacks the young and tender tissues of the rapidly growing weeds, causing their destruction, while there is little if any injury to the grain crop, particularly if it is a winter grain or one that was sown early in the spring, so that the crop has gained considerable growth before the spraying.

Investigations at the North Dakota Station with chemical means for the control of weed pests have shown that in addition to weeds in fields, such persistent weeds as dandelions may be eradicated in lawns, parks, and meadows by thorough spraying with the iron sulphate solution without any injury to the lawn or pasture grass. In the region about Fargo, where the experiments were conducted, spraying once a month or every six weeks throughout the year was found to keep the dandelion in check. For spraying lawns the application should be made a few days after the grass has been cut, with a solution of about 2 pounds of iron sulphate to a gallon of water. The spray should be forcibly applied, not merely sprinkled over the weeds, on a bright sunshiny day, and the lawn should not be mown for two or three days after the spraying. Heavy rains soon after the spraying will destroy the weed-killing power of the solution. Wherever chemicals are used for weed eradication on lawns it will be found advisable to scatter grass seed over the lawn each spring and fall.

In many regions alfalfa and clover fields are infested with dodder, a parasitic plant that may be recognized by its yellow, thread-like stems which entwine the plants. Hiltner[a] says that dodder may be destroyed by spraying infested areas with an 18 to 20 per cent solution of iron sulphate. The immediate effect of the chemical is to blacken the clover or alfalfa, but after a short time the crop recovers and is as vigorous as ever, while the dodder has been completely destroyed. In South Africa,[b] spraying alfalfa with sodium arsenite at the rate of one-half pound to 5 gallons of water when well applied was found to destroy dodder with little injury to the alfalfa.

MARKET CLASSES AND GRADES OF SHEEP.[c]

A recent bulletin of the Illinois Station, by W. C. Coffey, defines and illustrates the various classes and grades of sheep recognized on the Chicago and other large markets. The information is intended to aid those engaged in growing and handling sheep to understand and apply the market reports.

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[a] Prakt. Bl. Pflanzenbau u. Schutz, n. ser., 6 (1908), No. 4, p. 40.

[b] Agr. Jour. Cape Good Hope, 32 (1908), No. 2, p. 152.

[c] Compiled from Illinois Sta. Bul. 129. For classification of other farm animals see U. S. Dept. Agr., Farmers' Buls. 222, p. 24; 334, p. 22.

The grower or feeder offering sheep for sale often forms a very imperfect estimate of their market value, and chiefly because his contact with the open market has not been sufficient to familiarize him with the factors embodied by the various terms in market reports. * * * Because his judgment as to the true market worth of his sheep is uncertain, the owner may suffer a financial loss in dealing with a local buyer by selling under the market value or by missing a sale by asking too much for them. If, at the time of sale, the owner could definitely determine the value of his sheep, he would experience less difficulty in coming to an early understanding with the local buyer, or in case he shipped them direct to the open market, the chances for disappointment and dissatisfaction would be greatly reduced. While it is the privilege of a few to visit the markets often and there learn the requirements and the demands for the different grades in the various classes, the great majority of sheep owners, and many feeders, must depend largely upon the market reports for such information, and the value of these reports to the man who proposes to buy or sell sheep is determined by the extent to which he can apply them to his particular purchase or sale.

MUTTON SHEEP.

Under this head are classed "all sheep and lambs sent to market for slaughter, no matter what the condition, age, or weight," including both native and western sheep.

Native sheep are those produced, ordinarily in small flocks, on the farms of the Central, Southern, and Eastern States. Western sheep are those produced, usually in large bands, on the ranges of the Western States. As a rule, western sheep have enough Merino blood to make them markedly different in appearance from natives which are mostly from mutton-bred parents. But even were they identical in breeding, buyers and salesmen on the market could easily distinguish between them because of differences resulting from the way in which they are fed and managed. On markets where both native and western sheep are received, the daily reports nearly always distinguish between them, but in this bulletin no attempt is made to classify them separately where they are both put to the same use. Hence both native and western sheep are placed in the mutton and in the breeding classes, but only western sheep are placed in the feeder class. While thin natives are often bought up in the country and successfully fed, those that reach the market in low condition do not sell as feeders because they are usually infested with internal parasites, thus making it difficult and in many instances impossible to fatten them.

It is stated that a common practice is "to prefix the word 'fed' before a certain class and grade to distinguish grain from grass-fattened sheep. The term is used for a short time in the autumn and in the spring when both grain and grass fattened sheep are coming to market."

Lambs.—Of the various subclasses of mutton sheep "the one known as 'lambs' is by far the most important, due to the fact that the producer can most profitably market his sheep as lambs and also that lamb is preferred to mutton by the consumer. * * *

It is estimated by traders upon the Chicago market that at least 80 per cent of the sheep received at that place are lambs. * * *

At from 12 to 14 months of age lambs pass into the yearling and ewe classes. But it is the degree of maturity the young animal has attained rather than a set, definite age which determines whether or not it belongs to the lamb class. Native lambs usually reach maturity at an earlier age than western lambs, because they receive a greater abundance of feed, and they are generally free from Merino blood. * * *

The most important factors in determining the grade to which lambs belong are form, quality, condition, and weight, and the grades recognized on the market are: Prime, choice, good, medium, common, or culls.

It is understood that when lambs are graded as prime they are the very best of the class that may be generally expected on the market. * * *

Before a lamb is graded as prime it is determined by sight and touch that it possesses the form, quality, condition, and weight demanded by the dealer in high-class mutton. The butcher demands the form that shows the most development in the loin, back, and leg of mutton. He demands development in these regions because they are the parts from which the high-priced cuts are secured. The animal should show a great deal of depth and breadth and no tendency to be paunchy, because paunchiness adds to the percentage of waste in slaughtering. The prime lamb should present a general fullness and smoothness of outline, both of which indicate thickness and evenness of flesh. There should be an absence of roughness because the waste in the dressing of the rough, ungainly lamb is large in proportion to the carcass, and, furthermore, the appearance of the carcass of such a lamb fails in attractiveness when placed on exhibition in the market. It is generally conceded that form is enhanced if the body is supported by short legs. However, many prime lambs have only moderately short legs. Very long legs detract from the dressed yield and from the appearance of the carcass when displayed, and on this account lambs that are decidedly upstanding do not grade as prime. * * *

General quality is indicated by a medium sized, clean-cut head, ears of fine texture, and fine but strong bone, a light pelt, and full, well-rounded outlines. All these suggest a freedom from that coarseness which adds to the waste in dressing, and the unattractiveness which works against the value of the carcass. Of the items of general quality enumerated, lightness of pelt is the most essential. By pelt is meant the skin and wool combined. To secure a pelt of light weight, the skin should be comparatively thin and free from folds or wrinkles, and the wool should not be very dense or oily. * * *

"The weight of a pelt may be appreciably influenced by the condition of the wool with reference to foreign material and moisture in it," the presence of large amounts of these greatly reducing the price that will be offered.

Occasionally the general quality of lambs may be developed to such a marked degree that they will sell as prime, even though they be somewhat deficient in form. A notable example is the fat Mexican lamb. From the standpoint of form the Mexicans are not especially attractive, since they are upstanding and have narrow bodies and long necks, but they are unequaled in the fineness of their features and their lightness of pelt. Without their high development of general quality they would not receive favorable consideration from buyers, but because of it, when fat, they top the market.

The terms "quality" and "condition" are frequently used interchangeably on the market, and chiefly because the quality of flesh is largely dependent upon condition. By condition is meant the degree of fatness of a lamb. The reasons why a lamb should be fat are: (*a*) Other things being equal, there will not be as high a percentage of offal as in the half fat or the thin lamb; (*b*) the fat adds to the attractiveness of the carcass, and thus makes it more inviting to the purchaser; (*c*) the comparatively fat carcass loses less in weight in the process of "cooling out" in the refrigerator and also in cooking; (*d*) some fat on the outside of the lean meat and a considerable amount deposited through it adds to its palatability by making it more juicy and of better flavor.

Desirable quality of flesh is indicated by firmness along the back, at the loins, over the sides, and at the leg of mutton. * * * While the flesh should have that firmness which would impress an inexperienced man as being hard, it should have just enough springiness to yield slightly to the touch. * * * The development of fat essential to the prime lamb is indicated by a thick dock, a full, mellow purse, thickness and smoothness on the back and over the ribs, fullness at the neck and flanks, and a plump, well-filled breast.

It is impossible to tell with exactness, by merely looking at it, the condition of a lamb in the wool, and hence it is necessary to judge condition by placing the hands on the animal. Experts rely upon placing the hand but once, for example, by spreading the hand so that the back and ribs will be touched by one stroke, or by grasping the loin, or by getting the thickness and fullness of the dock, but none risk their judgment upon sight alone. A great deal is determined by the stroke that touches the back and ribs because it not only reveals the condition as evidenced by the degree of smoothness present, but also the amount and quality of the flesh by the thickness and firmness of it. This stroke also aids in determining the kind of pelt a lamb may have with respect to thickness of skin, density of wool, and foreign material in it.

Weight is a factor that varies somewhat with the different seasons in the year, but in general the lamb of prime quality and condition and weighing 80 pounds sells at the highest price. When spring lambs first appear on the market, they weigh little more than 60 pounds, but if they have the quality and finish, they easily command top prices.

The requirements of form, quality, and condition in case of prime lambs apply also in case of prime yearlings, prime wethers, and prime ewes.

To grade as choice, lambs can not fall below the requirements for prime lambs to any marked degree. They must have the form, quality, and condition that make them desirable as mutton of a high class. They usually fail to sell as prime lambs because they are not quite up to the standard in quality, condition, or weight. While lambs frequently fail to grade higher than choice because of their quality or their weight, a lack in condition is most often the retarding factor. This is the grade that includes by far the greater number of the better offerings upon the Chicago market. * * *

Upon the market, buyers and salesmen often prefer to speak of a band of lambs as being "good to choice" rather than using either of the terms separately to describe them. This, doubtless, is partly due to the unevenness in bands of lambs, which suggests two grades rather than one. If there is a pronounced unevenness in an offering, that alone is sufficient to prevent them grading better than good. But the individual lamb must be noticeably deficient in form, quality, condition, or weight, or slightly deficient in each, thus making a lower grade through a combination of deficiencies.

Lambs of the medium grade lack to a large extent the condition and quality necessary in the prime lamb.

It is in this grade more than any discussed above that faulty form is apparent. Long, loosely coupled bodies, with little spring of rib, and rough outlines are frequently seen. Because they are coarse, underfinished, and often paunchy, they do not dress a high percentage, and what they do produce is without sufficient fat to meet favor with dealers who handle high-class mutton. Only the coarser, heavier pelted western lambs are found in this grade, as the smoother, tidier range lambs in underfinished condition are sold to go to the country as feeders. Many native lambs, however, come in this grade, because those appearing on the market in low condition or those on the coarse " bucky " order are not sought as feeders.

Lambs are in the common or cull grade chiefly because they are very far below that condition of flesh that would make them desirable for mutton.

Coarse, ill-shaped lambs commonly belong to this grade, but not unless they are noticeably lacking in quality of flesh and amount of fat. Offerings in this grade are very light in weight, the range, with the one exception (coarse, "bucky" natives), being from 30 to 50 pounds.

As practically all native lambs appearing in the market go to slaughter while thinner western lambs are sent to the country as feeders, natives form the bulk of the common or cull lambs.

Under present methods of sheep husbandry, it is impossible to send all native lambs to market in desirable condition, because growers of natives have not yet learned how to keep them free from infestation by internal parasites, and when they are infested to any great extent they do not take on fat.

In both the common and medium grades are frequently seen what are known as coarse, "bucky" native lambs. These are the result of careless shepherding on the part of growers. If lambs are left entire they rapidly become coarse when their sex instinct develops, and because of this coarseness and the loss of fat resulting from a great amount of fretful activity, they are undesirable as mutton. * * * Growers of natives would save much to themselves annually if they would make it a practice to castrate their ram lambs a few days after they are born. These coarse, "bucky" lambs are heavier than the bulk of common lambs, as they sometimes weigh as much as 100 pounds.

The term "cull" is common parlance in sheep market circles, but it has a double meaning. One applies to the lowest grade under a given class, and it is in this sense that the writer uses the term; the other, to the number a buyer may have the privilege to reject when purchasing a band of lambs or sheep at a given price. Therefore, in defining the lowest grade of lambs, the term "common" is less confusing than the term "cull."

Yearlings.—Yearlings of a certain grade are used as substitutes for lambs in the meat trade.

The ability of the animal to substitute in this way depends upon its weight, quality, condition, and immaturity. An index greatly depended upon for identifying the carcass of a young sheep, or lamb, is what is known as the "break joint," which is found immediately above the pastern point. The leg easily severs at the "break joint," leaving a reddish, porous, indented surface, over which there is a slight, viscidlike secretion easily noticeable to the touch. The presence of this joint in the live animal is best determined by feeling just above the pastern joint for a bonylike prominence, which is a true indication of it. It disappears when the sheep becomes mature, and a sheep that does not have it can not class as a yearling. The yearling class is composed exclusively of wethers, because the "break joint" disappears in ewes at about the time they pass out of the lamb class. Lambs born the year previous to the time they appear on the market pass out of the lamb class about July 1, and from that time the wethers are called "yearlings" until they are too far toward maturity to "break," as the salesmen and buyers familiarly refer to the "break joint."

Yearlings are commonly designated upon the market as "lights" and "heavies." These terms, as they would indicate, refer to weights. Thus we frequently hear the phrases "prime lights" and "prime heavies," by which is meant the quality and condition of animals coming within certain limits of weight rather than their desirability as mutton. And, hence, it is felt that "lights" and "heavies" are not strictly logical terms upon which to base gradations in this class.

Since yearlings are used to take the place of lambs, the nearer they approach the quality, condition, and weight of prime lambs the more satisfactorily will they accomplish the purpose for which they are intended. Any great departure in any of the above characteristics as applied to prime lambs will seriously affect the desirability of yearlings, and if they are low in condition they are practically out of consideration as such.

The grades of yearlings are prime, choice, and good.

Yearlings, to grade as prime, must be highly developed in form, quality, and condition, and of a light, handy weight, which ranges from 70 to 90 pounds. The form of the prime yearling embodies symmetry, compactness, roundness, and smoothness, with no suggestion of uneven lines or prominent parts. Unless such a form is secured, the carcass will appear too great in size to look like a lamb. In general quality the requirements are fine, clean-cut features and a pelt of light weight. As with prime lambs, so with yearlings, a high dressed percentage is demanded, and this is not possible with the animal having very coarse features and a heavy pelt.

The most important considerations in placing a yearling in the prime grade are quality of flesh and the amount of fat it carries. Slight concessions may be made to a lack in general quality and form, but none to a lack in fat. Unless fat the yearling is unsatisfactory, hence buyers discriminate sharply against those not showing a high finish.

Since it is difficult to secure the most desirable form, quality, condition, and weight combined in one animal, choice yearlings outnumber those of the prime grade. Any noticeable departure from what is considered prime in any of the above characteristics is sufficient to place a yearling in the choice grade. During the winter season, when the offerings of sheep are almost wholly grain fattened, the greater number of yearlings are in prime condition; but at all times there are offerings that are not of the most desirable form, quality, and weight. * * * Those of more than 90 pounds weight, although they may be in prime condition, rarely grade better than choice. * * * There can not be a great difference between the condition of prime and choice yearlings, and, in fact, the total difference between them is not great.

Undesirable quality, weight, or condition, or a combination of deficiencies in any two or all three of the above, will, if readily apparent, place a yearling in the good grade. With a few scattered exceptions this is the lowest grade of yearlings offered as mutton. Yearlings of 110 pounds and upward rarely grade better than good, even though they be prime in every other respect. Ill form, general coarseness, and undue weight of pelt are all serious objections, and those having such defects are nearly always placed in this grade. A rather frequent combination, placing yearlings in the good grade, is underfinished condition and undesirable quality. If yearlings are assigned to this grade solely because of a want of fat, they are almost on the border line between the mutton and the feeder class, and are not much wanted by either packers or feeder buyers.

Wethers.—Mature castrated males compose this subclass.

Since comparatively few native wethers appear upon the market this class is looked upon as chiefly a western product. * * *

The same conformation, quality, and condition are demanded in prime wethers that have already been noted as characteristic of prime yearlings. The most desirable weights range from 95 to 110 pounds, and are popularly known as "light handy weights." However, wethers weighing 140 pounds and upward frequently grade as prime if their heavy weight is accompanied by desirable conformation, quality, and condition.

The choice wether is usually slightly short of prime in form, quality, and condition. Quality in this instance applies more particularly to lightness of pelt and to freedom from paunchiness than to coarseness of features. Wethers of this grade must also come under the light, handy, or the heavy weights. Choice wethers are used in the same way as prime wethers, and both are sought by dealers in high-class mutton.

Good wethers are characterized by coarseness and lack of prime condition. They do not command the highest prices because they do not dress a high percentage of marketable meat nor yield a quality of mutton satisfactory to a high-class trade. If wethers are pronounced in their weight of pelt, but covered with thick fat, they will come in this grade unless of undesirable weight. Frequently wethers of choice condition and quality, and weighing 120 to 135 pounds, are placed in the good grade because their weight is not adapted to the purpose for which they are desired. They are too heavy for light, handy purposes, and too light for heavy carcass purposes.

The common grade is made up of wethers of inferior quality and in perceptibly underfinished condition.

Ewes.—In this subclass are included yearling ewes, surplus breeding ewes, and those no longer useful for breeding purposes.

As these different sources indicate, there are wide differences in the age, condition and weight of the various offerings of ewes appearing on the market.

Ewes do not sell on a par with wethers, because they have proportionately a greater percentage of offal and a smaller amount of lean meat. Except in times of urgent demand for mutton, prime wethers sell for at least 50 cents per hundredweight more than prime ewes. However, when the demand for mature mutton is strong the difference is often no more than 25 cents. * * *

Smooth, highly finished native and western yearling ewes, and a very small number of well-bred, aged native ewes, of prime quality and in prime condition, comprise the offerings in [the prime] grade. Since the bulk of yearling ewes are sold for breeding purposes, the total offerings of prime ewes are small. Prime yearling ewes may be not entirely above criticism in quality and condition, but because they are light in weight they meet with ready sale. The strongest demand is for weights not greater than 100 pounds. However, large, smooth, aged ewes in prime condition sell as prime ewes. * * *

Ewes of [the choice] grade must show development to a high degree in form, quality, and condition, as they are placed to the same use as prime ewes. They may be slightly faulty in quality, condition, or weight, but they are usually criticised for their lack either of quality or condition. Grain-fattened western ewes frequently sell as choice.

Good ewes are appreciably open to criticism in condition and often in quality. In most seasons of the year ewes choice in condition and quality, but of the unhandy weights ranging from 115 to 130 pounds, are also placed in this grade.

Underfinished condition and advanced age are usually evident in the medium grade. "Often ewes and their lambs are sent to market together. Ewes in such shipments are frequently too low in condition to be above the medium grade."

Offerings of the common or cull grade are pronounced in their lack of condition.

Toothless old ewes, too decrepit to make use of feed, and thus regain desirable condition, are slaughtered for the cheapest class of trade. As the winter season advances a number of ewes appear on the market well advanced in pregnancy. Such ewes, although they may be of choice quality and condition, sell as common ewes because of their high percentage of waste and the ill effects pregnancy is said to have upon the color of the carcass.

BUCKS AND STAGS.

On the market rams are designated as "bucks." Stags are males castrated later than the lamb stage of life, and they sell on a par with bucks. Strictly speaking, bucks are not graded, although the terms "choice," "good," and "common" are frequently used.

FEEDER SHEEP.

Whenever sheep are too low in condition to suit the needs of the packer, they fall into the feeder class, unless they be extremely coarse in quality or weakened in vitality because of disease or advanced age.

The heavy run of feeder sheep occurs in the months of September, October, and November, when rangemen are reducing their flocks and preparing for the winter months. However, buyers are constantly looking for thrifty, underfinished stuff and a limited number of feeder sheep go out from the markets every week in the year. * * * Practically all the sheep sold as feeders are grown on the western ranges. * * * The following are the recognized subclasses of feeder sheep: Lambs, yearlings, wethers, ewes.

Lambs.—Feeder lambs are those thin in flesh left after sorting out those in a band in suitable condition for the mutton trade. The grades recognized on the market are fancy selected, choice, good, medium, common, or inferior.

Fancy selected feeders must not only possess the characteristics of choice feeders, as noted [below], but in addition they must be uniform in breeding and markings and show an unusual amount of mutton blood for range lambs. Their quality, as evidenced by clear-cut features, clean limbs, light and smooth pelts, must be practically above criticism. They are nearly always slightly higher in condition and heavier than the average run of feeder lambs, ranging in weight from 65 to 70 pounds, and in that state of thrift where gains can be placed on them rapidly. If properly handled, they are the grade of feeders that will finish quickly into prime lambs. Not many of this grade of feeders are to be found on the markets. * * *

Choice feeders will develop into choice and prime mutton lambs if properly managed. Of the grades that come to the notice of buyers generally, they are probably more uniform than any other, and in order to get a fixed standard from which to make comparisons, this grade is described in detail.

What the buyer expects of choice feeders is the ability to finish into prime or choice mutton lambs, and to produce gains at economical figures. The selection of such lambs is based upon form, quality, constitution, condition, and weight.

In general, the form should be deep, broad, well knit, of medium length and low set. This conformation indicates early maturity, good constitution, capacity for growth, and a likelihood of finishing into an attractive carcass with a relatively high percentage of valuable cuts. * * *

Quality is a very important consideration in the selection of feeder lambs, and it is that characteristic which is manifested by a medium-sized, fine, clean-cut head; medium-sized and moderately thin ears; the hair on the face and legs fine and silky; bone that is fine and without coarseness at the joints; skin thin and without folds or wrinkles. A smooth skin without folds or wrinkles and carrying wool of moderate weight is the most important requirement of desirable quality in feeder lambs. * * *

The conformation which indicates a strong constitution was described above under " Form." A wide, deep chest, fullness in the heart girth, depth and breadth of body indicate sufficient space for well-developed vital organs, or strong constitution. Another important point, which if not a part of constitution is closely akin to it, is thrift. The intelligent buyer of choice feeders rejects all lambs that appear in the least unthrifty, such as lame ones and those inclined to lag behind when the band is moving.

Choice lambs should be fairly full in their outlines and without any suggestion of emaciation. Choice feeder lambs range in weight from 55 to 62 pounds.

Good feeder lambs are usually more leggy and coarse than those that are considered choice. Lambs weighing between 50 and 55 pounds and choice in form, but somewhat, although not excessively, heavy in pelt, are placed in the good grade.

Lambs of the medium feeder grade often have very heavy pelts, and hence lack appreciably in quality.

Pronounced legginess and angularity of form are frequently noticeable in bands of lambs grading as medium, but the chief discrimination is against their quality because of their thick, wrinkled skins and dense, heavy fleeces. While in most cases they are thrifty, they are usually below the weight most desirable in feeder lambs, and this, together with their lack of quality and desirable form, places them considerably below the choice feeder.

The lambs most common to the grade of common or inferior feeders are little, light, late-born, weak lambs.

They are known under several appellations, such as "bums," "culls," "pewees," and "peanuts." Their weight may vary anywhere from 25 to 45 pounds, and because of their tender age, light weight, and weakened condition they require skillful care and a long period of feeding upon nutritious feeds that will produce a large amount of growth as well as fat.

The demand for this grade is limited.

Yearlings.—This class is made up exclusively from yearling wethers. They do not figure prominently in the feeder trade. They are graded as choice, good, common.

Wethers.—Of the wethers sold from the range for feeding purposes the greater number is shipped direct to western feed lots, hence the supply on the Chicago market is extremely meager. The grades are choice, good, medium, common.

To be considered choice feeders, wethers must be of good conformation, highly developed in quality, and uniform in weight and condition. * * * The choice feeder wether should be of a light, handy weight, which ranges from 80 to 90 pounds.

Good feeder wethers should be uniform in weight and condition, and not open to serious criticism in conformation and quality. Wethers of this grade are usually inferior to those of the choice grade in quality or condition.

Wethers of the medium feeder grade are usually criticised for their lack of quality and condition. Medium feeder wethers are likely to be large of frame, and although not heavy at the time of purchase because of their thin condition, they are heavy wethers when marketed as mutton.

Extremely coarse wethers with heavy pelts, stags, the result of castrating mature rams, and very old wethers are included in the common feeder grade.

Ewes.—" When there is a slow demand for breeding ewes * * * the yearling ewe lops off into the feeder class. Of the mature ewes sold as feeders, the larger number are those that have spent their usefulness as breeders on the range. They vary considerably in condition, quality, and general thrift, and all feeder ewes may be graded as follows: Choice, good, medium, common."

Most of the yearling ewes offered as feeders are placed in the choice grade.

They are of choice quality and in that degree of condition at which gains are put on rapidly and early give a degree of desirable finish. They weigh from 70 to 80 pounds and when finished yield a neat, handy weight carcass. Smooth, aged ewes of good form and in medium flesh are also placed in this grade.

To grade as good, feeder ewes must be smooth and healthy, and their teeth must be sound.

Ewes of the medium feeder grade may be lacking either in quality or thrift. If unthrifty, they are usually broken mouthed and in low condition.

Common ewes are very old and so depleted in condition that they approach emaciation. As a rule their front teeth are gone or worn so low that they are of little use. Only the best of care and feed will secure gains on ewes of this grade.

BREEDING SHEEP.

Native and western ewes are included in this class in about equal proportions, but breeding bucks are exclusively natives.

Ewes.—The ewes most sought after are 2, 3, and 4 year old dark-faced natives in ordinary field condition. * * * Many of the ewes offered for breeding purposes are yearlings, but they are not as desirable as 2 or 3 year old ewes, because they are immature and likely to be unsatisfactory as mothers at their first lambing. The native yearling is heavier and more nearly mature than the western yearling, and she meets with a correspondingly better sale. The offerings on the market come under the following grades: Fancy selected, choice, good, common.

Only a very few of the breeding ewes sold out of the market can be regarded as fancy selected. * * * Such ewes are high grades of some of the Down breeds, usually Shropshire, and in addition to being thrifty and sound, they are uniform in quality, conformation, fleece, and style.

The greater number of the more desirable breeding ewes are of the choice grade. Choice ewes should be 2, 3, or 4 years old, sound in mouth and udder; Down breeds preferred.

The smooth, low-set, symmetrical ewe is preferred over the angular, upstanding ewe with uneven top and lower lines. * * * Choice breeding ewes should have smooth, rather refined features and bone of medium size. * * * While choice breeding ewes should be thrifty and active, fat is not desirable. * * *

Several factors combined cause breeding ewes to grade as good, such as undesirable markings, age, weight, conformation, and condition.

Common breeding ewes are on the border line between breeders and feeders. They show no single line of breeding. In many instances they are noticeably advanced in age.

Bucks.—While the rams sold out of Chicago market as breeders vary in age, weight, and markings, there are no recognized grades. Those most sought after are dark-faced, smooth, low-set, vigorous-looking rams of a year or more in age. * * * Inspection of rams selected for breeding out of the open market reveals the fact that the greater percentage show undesirable form and a mixture of breeding.

MISCELLANEOUS.

Hothouse lambs (spring lambs).—The term "hothouse lambs" refers to those produced early and marketed before the general run of spring lambs start to market, which is about May 20. * * * "Hothouse lambs" are most in demand from Christmas until Easter. They must be fat and weigh between 40 and 55 pounds.

Export sheep.—Most of the sheep selected for export are the heaviest of their class. They are usually in prime condition and of the choice grade. Wethers are preferred, but ewes, yearlings, and lambs are also taken, hence the term "export" can not be said to apply to any particular subclass of mutton sheep. Many buyers use the term freely to designate wethers, yearlings, ewes, and lambs heavy in weight and prime in condition, whether they be taken for export or not.

Throw-outs.—This is a term applied to lambs rejected as feeders. After a band of lambs has been divided into the mutton and feeder classes, the purchaser of the feeder end usually has the privilege of rejecting those not suitable for feeding purposes. Lame lambs, those appearing unthrifty, entire males, those large enough to be suspiciously near the short yearling age, and frequently black lambs make up the rejections. * * * Throw-outs are often called "rejects," but they are never known as "culls" or by any of the terms which denominate the grades under the regular classification. Sometimes they sell on a basis of cull lamb prices, at other times upon that for medium lambs.

Dead sheep.—These are sheep that meet with death in transit. Losses are greatest in warm weather, when deaths are frequent if close crowding in the car is practiced. * * * Dead sheep have a value chiefly for their wool. The best are worth 25 cents per head. It is claimed that 50 per cent of them are worthless on account of the wool being mangled and trampled off.

Goats.—Goats are sold for slaugter provided they are in good condition, but they do not sell on a par with sheep. Only a few are sold on the Chicago market, and hence they are not graded.

The different classes and grades which have been described are summarized in the following table:

Summary of classification of sheep.

Classes.	Subclasses.	Grades.
Mutton sheep (native and western sheep)	Lambs	Prime.
		Choice.
		Good.
		Medium.
		Common or culls.
	Yearlings	Prime.
		Choice.
		Good.
	Wethers	Prime.
		Choice.
		Good.
		Common.
	Ewes	Prime.
		Choice.
		Good.
		Medium.
		Common or culls.

Classes.	Subclasses.	Grades.
Feeder sheep (western sheep)	Bucks and stags	Choice. Good. Common.
	Lambs	Fancy selected. Choice. Good. Medium. Common.
	Yearlings	Choice. Good. Common.
	Wethers	Choice. Good. Medium. Common.
	Ewes	Choice. Good. Medium. Common.
Breeding sheep (native and western sheep)	Ewes	Fancy selected. Choice. Good. Common.
	Bucks	(Not graded).

Miscellaneous:
- Hothouse lambs.
- Export sheep.
- Throw-outs.
- Dead sheep.
- Goats.

VETCH HAY AND VETCH SILAGE AS FEEDS FOR COWS.[a]

Common vetch (*Vicia sativa*) is a great nitrogen gatherer and is used as a farm crop in many different ways. In some localities it has proved valuable as a catch crop and also as a cover crop in orchards. In France it has been grown to furnish honey-making material for bees. In the eastern United States the common vetch has not proved to be so valuable as other legumes, but in western Oregon it has become a standard stock feed and is used as hay, silage, pasture, and as a soiling crop. It makes a very palatable hay and dairy cattle prefer vetch silage to that made of red clover. On some farms vetch is replacing clover in the regular rotation. Vetch is usually sown in the fall with wheat or rye to support the stalks, and is cut for hay when the seeds begin to form in the pods. Under western

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[a] Compiled from Oregon Sta. Buls. 85, 91, 102; Rpt. 1905.

Oregon conditions of soil and climate it yields from 2 to 4 tons of hay to the acre. The seed crop yields from 15 to 30 bushels per acre.

Vetch is a heavy feeder on soil potash. At the Oregon Station the per cent of ash found in water-free vetch was 8.2. The ash contained 37.5 per cent of potash and 10.02 per cent of phosphoric acid. Calculating at the rate of 3 tons of cured hay to the acre, a crop of vetch will remove 150 pounds of potash and 40 pounds of phosphoric acid. As a dairy feed vetch is prized for its high protein content, though it is quite variable. In 10 samples examined in 1903 protein varied from 14.63 to 21.31 per cent, with an average of 17.39 per cent; in 80 samples examined in 1904 protein varied from 12.19 to 23.31 per cent, with an average of 18.03 per cent; and in 152 samples examined in 1905 protein varied from 9.65 to 25.52 per cent, with an average of 18.85 per cent.

In experiments with cows at the Oregon Station the digestibility of the protein of vetch hay varied from 61.07 to 69.91 per cent, of carbohydrates from 70.71 to 71.59 per cent, and of fat from 68.01 to 71.21 per cent. The digestibility of the protein of steamed vetch silage was 14.62 per cent, of unsteamed vetch silage 56.38 per cent; of the carbohydrates of steamed vetch silage 62.83 per cent, of unsteamed vetch silage 66.85 per cent; of the fat of steamed vetch silage 62.91 per cent, of unsteamed vetch silage 77.34 per cent.

From these experiments it will be seen that vetch hay and vetch silage must be considered as valuable protein feeds for dairy stock, and that steaming vetch silage reduces its digestibility. "Over 56 per cent of the protein in the unsteamed silage is digested, while less than 15 per cent of that in the steamed silage is utilized by the animals. The average per cent of dry matter, ash, fiber, and fat digested is from 10 to 14 per cent lower in the steamed silage. The digestibility of the extract, or carbohydrates, is approximately the same in each."

DIGESTIBILITY OF KALE.[a]

Thousand-headed kale (*Brassica oleracea*), introduced into the Willamette Valley, Oregon, twenty-seven years ago, has become one of the most valuable succulent dairy feeds in the State. It received the name "thousand-headed" because of the numerous branches when given plenty of room in which to grow. It does not head up like cabbage, but looks more like rape, though the plants are taller and the leaves are longer and broader. The plant can endure cold weather, and in the Oregon climate stands in the field all winter. It is hauled to the barn and fed green from October to April at the rate of 25 to 50 pounds per day to each animal. In the early part of the feeding season only the lower leaves should be used, as there will be too much loss in feeding the whole plant. Kale should not be fed when frozen, nor should it be allowed to remain in piles where it will heat, and it must be fed just after the milking period to avoid tainting the milk. A single plant sometimes weighs 30 pounds. A yield of 30 to 40 tons of green kale to the acre is not uncommon. At the Ontario Experiment Station, from 1904 to 1907, the average yield of thousand-headed kale per acre was 27.1 tons; of hardy curled kale, 20.3 tons; Jersey kale, 19.8 tons; tall green curled Scotch kale, 19.3 tons.

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[a] Compiled from Oregon Sta. Buls. 91 and 102; Ontario Agr. Col. and Expt. Farm Rpt. 1907, p. 217; U. S. Dept. Agr., Bur. Plant Indus. Bul. 94.

Chemical analyses made at the Oregon Experiment Station show kale to be very rich in protein and mineral matter. One hundred pounds of fresh kale contained 11.3 pounds of dry matter, 2.4 pounds of protein, 0.53 pound of fat, 4.98 pounds of carbohydrates, 1.54 pounds of fiber, and 1.84 pounds of ash.

> Calculated to the acre yield of 30 tons, these values show that approximately 225 pounds of potash and 115 pounds of phosphoric acid enter into the composition of each acre of kale. This shows the plant to be a heavy feeder on these plant foods and proves the necessity of a rich soil for its successful growth.

At the same station feeding experiments were made with cows to ascertain the digestibility of kale. Fresh kale was fed in amounts varying from 50 to 80 pounds per cow per day. The average per cent digested was as follows: Dry matter, 68.01; protein, 80.63; fat, 65.85; carbohydrates, 75.83; fiber, 58.99; ash, 38.81, indicating that "a large proportion of the protein in the kale is digestible, an average of 80.63 per cent being obtained from the four tests. The percentage of digestibility of the other constituents is also normal or above, with the exception of the ash."

HULLED CORN.[a]

In a recent bulletin of the Maine Station, L. H. Merrill says:

> By treating corn with an alkali the hull or indigestible outer coating of the kernel may be so loosened that it can be easily removed. If the alkali is then thoroughly removed by washing and the product steamed, the result is the so-called "hulled corn," a very acceptable food with many.

In view of the fact that little or nothing is actually known of the digestibility of hulled corn as compared with similar articles of diet, Professor Merrill made a number of careful tests of the digestibility of the material when eaten with milk only and with a mixed ration of bread, butter, meat, and canned peaches. The composition of the hulled corn used in the experiments were as follows: Water, 80.24 per cent; protein, 1.9 per cent; fat, 1.05 per cent; carbohydrates, 15.04 per cent; fiber, 0.2 per cent; and ash, 1.57 per cent.

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[a] Compiled from Maine Sta. Bul. 158.

The digestibility of the hulled corn as determined in the experiments is shown in the following table in comparison with that of white (wheat) bread:

Digestibility of hulled corn and white bread.

	Protein.	Carbohydrates.
	Per cent.	*Per cent.*
Hulled corn, simple diet (average of 8 experiments)	81.7	97.3
Hulled corn, mixed diet (average of 8 experiments)	90.9	97.0
Hulled corn alone (average of 8 experiments)	61.2	96.4
White bread, simple diet (average of 7 experiments)	93.9	99.1
White bread alone (average of 7 experiments)	92.6	98.9

The above table shows that the protein of the hulled corn is much less digestible than that of the white bread, and that the carbohydrates (sugars, starches, etc.) are slightly less digestible, but that the hulled corn is more digestible when eaten in a mixed diet than when eaten alone or in a very simple diet. The latter fact illustrates a general truth, viz, that many food materials are more digestible when eaten in a mixed diet than when used alone.

METHODS OF MIXING FAT INTO DOUGH.[a]

The effect on quality of mixing fat into dough in different ways has been studied by Miss M. U. Watson, of the Ontario Agricultural College, who found in the case of biscuits in which the shortening had been mixed in the dough by rubbing or cutting into the flour, and by also mixing in the melted shortening, that equally good results were obtained as regards outward appearance and the way the dough had risen, but on breaking the biscuits made with melted butter they were found to be of inferior texture and seemed very tough, while in the biscuit in which the butter was rubbed into the dough the texture was much better, more spongy, and quite tender.

When these methods of mixing in fat were tested with cookies the samples were found to be very much alike after baking, one being as good as the other.

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[a] Compiled from Ann. Rpt. Ontario Agr. Col. and Expt. Farm, 33 (1907), p. 244.

361

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FARMERS' BULLETIN 361.

MEADOW FESCUE:

ITS CULTURE AND USES.

BY

H. N. VINALL,
Scientific Assistant, Forage Crop Investigations,
Bureau of Plant Industry.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 29, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin the accompanying manuscript on "Meadow Fescue: Its Culture and Uses," prepared by Mr. H. N. Vinall, Scientific Assistant in Agrostology in Forage Crop Investigations.

There is at present a great lack in the agricultural literature of this country of concise descriptions of the methods followed in the growing and handling of the different cultivated grasses, especially for seed production. This bulletin not only treats of the value of meadow fescue in meadows and permanent pastures, but also discusses in detail the production of seed and problems in connection with seed growing. The publication of such information should result in a wider use of this grass in pasture improvement throughout the East-Central States.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction........ 5
Culture of meadow fescue........ 8
  Soil........ 8
  Preparation of the seed bed........ 8
  Covering the seed........ 9
  Time of seeding........ 9
  The seed crop........ 9
  Hay........ 12
  Pasture........ 12
  Mixtures with other grasses........ 13
  Rotative value of meadow fescue........ 13
  Breaking up a meadow........ 14
Enemies of meadow fescue........ 14
  Rust........ 14
  Weeds........ 15
Meadow fescue in the East........ 16
Present importance and future of meadow fescue........ 18
Tall fescue........ 19
  Comparison of tall fescue with meadow fescue........ 19
  Seed habits of tall fescue........ 19
  Rust resistance of tall fescue........ 20
  Importance of tall fescue........ 21
Summary........ 22

ILLUSTRATIONS.

Page.
Fig. 1. Map of the United States, showing the meadow fescue region........ 5
2. Panicle of meadow fescue.. 6
3. Field of meadow fescue in shock, showing the bands at the top....... 11
4. Meadow fescue seed.. 15
5. Common cheat (*Bromus secalinus*) seed.......................... 16
6. Panicle of tall fescue.. 20
7. Tuft of tall fescue in bloom, showing foliage and seed habits........ 21

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MEADOW FESCUE: ITS CULTURE AND USES.

INTRODUCTION.

For the past twelve or fourteen years meadow fescue has been an important crop in northeastern Kansas. The acreage devoted to this grass has, however, been extremely variable. This fluctuating tendency is due chiefly to changes in the price of seed. The meadow fescue seed crop has in some years reached a total valuation of over $150,000 in the very limited section of the State indicated on the map shown in figure 1. The demand for meadow fescue seed is quite limited; hence, an undue expansion in production has caused in several years a decided fall in the price. The merits of the grass are such, however, that it is believed that a better knowledge of its usefulness will result in its being employed much more extensively, especially for permanent pastures throughout the timothy region.

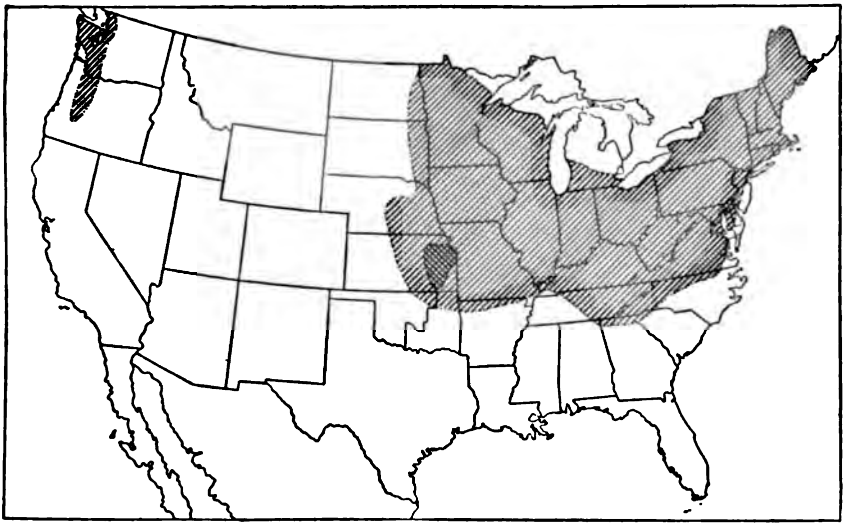

FIG. 1.—Map of the United States, showing the meadow fescue region. The cross-hatched portion in eastern Kansas indicates the area where most of the meadow fescue seed is now produced.

Meadow fescue (*Festuca elatior* L., *Festuca pratensis* Huds.) is also locally known as "English bluegrass," notwithstanding the fact that in England it is called meadow fescue. The name English bluegrass should be discarded for the established name meadow fescue, as the use of both leads to confusion.

Meadow fescue is a strongly perennial grass with long fibrous roots. The seed stalks ordinarily reach a height of 15 to 24 inches on upland soil, but on rich, black bottom lands they often attain a length of 3 feet or more. The stalks themselves are rather bare, but there is usually an abundance of basal leaves, which have a shining surface and an intense green color, thus presenting a very pleasing appearance in the spring and fall. The panicle is not so open as that of brome-grass (*Bromus inermis*) (see fig. 2) and as a rule is slightly drooping, so that the presence of meadow fescue in a field of brome-grass can easily be detected by those acquainted with the two grasses. Cases where meadow fescue seed has been used as an adulterant in brome-grass are not uncommon.

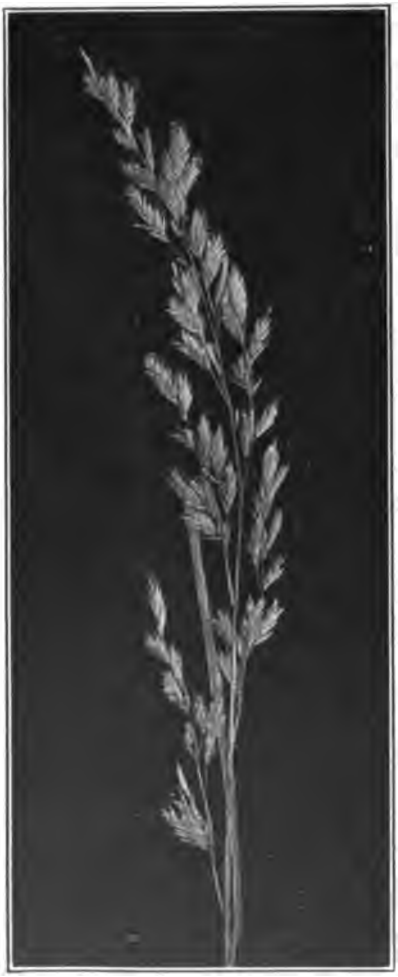

FIG. 2.—Panicle of meadow fescue.

Meadow fescue was early used as a constituent of the pasture mixtures sold by seedsmen, and in this way it has been introduced into most parts of the United States. It was brought to this country from Europe, probably from England, and until late in the eighties very nearly all of the seed used in this country was imported. This seed was of poor quality, weighing only 15 pounds to the bushel, and the light seed with its accompanying high price are prominent causes for the slow advance in favor of meadow fescue with farmers. Its utilization has not been more general chiefly because farmers do not realize the value of using mixtures of perennial grasses for pasture purposes, but cling persistently to bluegrass and timothy and red clover.

Meadow fescue sown alone furnishes scant pasturage during the hot summer months, and its lack of rootstocks prevents its taking first rank as a pasture grass in any region where Kentucky bluegrass does well. Its value at present is fully appreciated only in the eastern parts of Nebraska and Kansas. It is quite probable that in all the region indicated on the accompanying map (fig. 1), except perhaps the extreme northern and northeastern portions, an increase in the use of meadow fescue would have a very beneficial effect on the pastures.

The ability of meadow fescue to survive in wet places when trampled by stock keeps such places productive in pastures where timothy, red clover, and Kentucky bluegrass fail, and, besides being strongly perennial, meadow fescue has the additional advantage of coming quickly and surely from seed, producing in a short time a firm sod and considerable pasturage.

In the East meadow fescue has shown itself to be almost as well adapted as orchard grass to the clay soils, and though not quite as productive it is rather more palatable than the latter. As the value of tame pastures over native pastures is better realized, and as the English idea of mixtures is more firmly established with the American farmer, meadow fescue will take a more important place, at least as a pasture grass.

The southern limit of profitable meadow fescue culture is quite definitely located on a line running through northeastern Oklahoma and northern Arkansas, turning slightly toward the north through eastern Arkansas and western Tennessee, but dropping south again in the mountainous region of Tennessee and North Carolina, then turning sharply to the northeast, except for a slight curve in the Piedmont region of North Carolina, until it reaches the Atlantic on the southern point of Delaware.

While meadow fescue seems to be slightly more drought resistant than Kentucky bluegrass on account of its deeper root system, its western limit at present includes only the eastern parts of Nebraska, Kansas, and the Dakotas. The northern boundary is indefinite, depending to a great extent on soil and moisture conditions; in New York it is well north, while in Michigan, on account of the aversion of meadow fescue to sandy soil, it drops south. Very little is known at present of the behavior of meadow fescue in the New England States. Meadow fescue is also well suited to conditions on the Pacific slope of Washington and Oregon, but at present is not extensively grown there.

In the following pages the intention is to describe as accurately as possible the methods of culture applied to the production of meadow fescue in that part of the United States where it has become of the most importance, throughout eastern Kansas and southeastern Nebraska; also to point out its uses and indicate its value for other sections of the country where it is now used but sparingly.

CULTURE OF MEADOW FESCUE.

There is so little difficulty in getting a stand of meadow fescue that experienced farmers expect failure scarcely more often than in grain seeding.

Soil.—The soil best adapted to the production of meadow fescue is a heavy black loam. This grass has been noted growing in the most decided "gumbo" spots, and in these places, when the moisture was sufficient, no amount of trampling seemed to destroy it. It is not adapted to a light sandy soil, and the best yield of hay and seed is always secured from heavy soils rich in organic matter.

Preparation of the seed bed.—The seed bed is generally prepared by disking up a cornfield or plowing under grain stubble. The usual practice is to plow early in August, if convenient, then harrow and cross-harrow, firming the soil thoroughly and making it ready for seeding by the last of August. It is essential for the proper germination of any grass or clover seed to have a finely pulverized, well-firmed seed bed. This condition of the soil is best attained by the use of a subsurface packer followed by several workings with a spike-toothed harrow. Many farmers, however, do not have the packer, and as a substitute use the ordinary roller, loosening up the surface after it by attaching to the roller several sections of a harrow. This method is found satisfactory wherever tried, and in many cases means the difference between success and failure with grass seed. The roller should never be used when the ground is at all wet, and should always be followed by a harrow, so that the surface will not bake, but be left with a mulch of loose soil.

The amount of seed per acre used by different growers varies greatly. Throughout the fescue region, however, it is the most common practice to use from 10 to 15 pounds, and this amount is considered sufficient whenever a seed crop is the object. When seeded with a grain drill a half bushel usually produces an excellent stand and gives the best results. Most of the chief producers state that heavier seeding will give a larger yield the first year but that the field will soon become sod-bound and thereafter produce both a smaller quantity and an inferior quality of seed. A prominent grower of Lafontaine, Kans., however, declares that he has sown up to 1¼ bushels of seed per acre with good results, thereby both increasing his yield and freeing the field from weeds. Under this system he has had 100 acres average 20 bushels per acre. Many have found it very advantageous to sow clover in the meadow fescue, as it greatly improves the pasture, while the grass can be cut high for seed and leave a good hay crop of clover and fescue leaves to be cut later.

Covering the seed.—Meadow fescue seed can be sown broadcast and covered with a harrow as other grass and clover seeds usually are, but the general opinion is that a press or disk drill covering just a trifle more lightly than in sowing grain gives better results. This practice insures a uniform stand and maximum germination. For pasture purposes a double seeding, applied by cross-drilling 10 to 15 pounds each way, is suggested.

Time of seeding.—Undoubtedly the most popular time for seeding, as well as the best time for scientific reasons, is from August 15 to September 15, although many sow later with satisfactory results. The dates mentioned give the grass a good start in the fall and insure a seed crop the following season, thus avoiding the loss of a crop year in getting the grass started, as is the case in spring seeding. A field of 8 acres near Gardner, Kans., sown August 27, 1906, at the rate of one-half bushel per acre, was one of the best-appearing fields seen by the writer during 1907. It was harvested July 5, 1907, giving a yield of 18½ bushels of seed per acre.

The extreme adaptability of meadow fescue as to date of seeding is shown by another field near Gardner, Kans., which was sown for hog pasture on April 20 with a mixture of meadow fescue and timothy. May 20 the grass was about 4 inches high, covering the ground perfectly, with a large percentage of meadow fescue in the stand. In this vicinity meadow fescue is preferred to alfalfa for hogs, as it starts so much more vigorously.

It is seldom the practice to use a nurse crop. Fall-sown meadow fescue gives a seed crop the ensuing year, while from that sown in the spring nothing is expected except a little fall pasture until the second year.

The seed crop.—Heretofore the production of seed has been the most important consideration in the growing of meadow fescue, and has been the cause of the large acreage seeded in eastern Kansas. The market for seed has been uncertain, however, and as it depends to some extent on the foreign demand there has several times been an overproduction with consequent low prices and close grading, the farmer not being able to respond to the pulse of a foreign demand as easily as to a domestic one. It is the general opinion among the producers that 5 cents a pound is the minimum price at which it is profitable to grow meadow fescue for seed. The price paid farmers has varied in the past decade from 3 to 15 cents a pound.

The commercial seed production of meadow fescue was begun in 1877, near Gardner, Kans. It proved so profitable with the originator, Mr. S. H. Ayers, that his neighbors began to buy seed and engage in the production of meadow fescue seed in preference to wheat, as it was quite permanent when once seeded, furnished splendid pasture after being cut, and for many years a hay crop was secured from the stubble. The maximum production was probably reached in 1903, although 1896 was also a good crop year. In 1903 a conservative estimate places the amount of clean seed produced in Kansas as over 130 carloads of 30,000 pounds each. The 1906 crop was less than half this amount, and the 1907 crop showed a further decrease.

The price paid in 1903 for meadow fescue seed ranged between 3 and 5 cents, while in 1901 it was 14 and 15 cents. The high prices of 1901 caused the enormous acreage of the following years and the great oversupply of 1902 and 1903, many seed houses buying sufficient seed to fill their orders for a year or more ahead. Another cause for the decrease in acreage has been the rust, which has lately become destructive in the meadow fescue fields.

The grades of meadow fescue seed run opposite to those of wheat. After a car is examined the report is given in the percentage of chaff instead of that of pure seed, as 5 or 20 per cent instead of 95 or 80 per cent, meaning that 5 or 20 per cent of the bulk is trash or foreign seed. Grading has come to be a source of much discord between the grower and the dealer, since in years of overproduction the grading, which is at all times in the hands of the dealer, becomes more rigid and close.

Meadow fescue is harvested for seed just as the field begins to take on the yellowish brown cast characteristic of a ripening grain field and the heads begin to droop on account of their weight. This in ordinary years is between July 1 and July 10. The grass is cut with an ordinary grain binder and placed in small shocks for curing. Careful growers put four bundles only in each shock and bind the tops together with twine to prevent injury from storms and loss of color through bleaching (see fig. 3).

A large percentage of the growers thrash their meadow fescue directly from the field, hauling it to the machine on hayracks with canvas stretched over the bottom, which saves the seed that shatters out. However, thrashing from the shock is warrantable only because it saves labor. An ordinary grain thrasher is used in thrashing with no changes except the shutting off of most of the wind from the fan and the addition of a special screen, although this latter is not indispensable, as fairly good work can be done with an ordinary wheat riddle. The brightest and heaviest seed is obtained by stacking the fescue and thrashing after it has had sufficient time (six to eight weeks) to cure in the stack.

The yield of seed varies greatly. From 6 to 25 bushels per acre have been reported; 15 bushels is considered a good yield, and the average probably lies between 8 and 12 bushels. First-class seed weighs about 25 pounds per bushel. Opinions differ as to the advisability of pasturing meadows which are to be used in seed production. A considerable number of farmers who have large stock interests claim that they are able to pasture for a short time in the spring and again throughout the fall without injuring the seed harvest. Observation would lead to the belief, however, that the largest yields are obtained from fields which are not pastured in the spring and very judiciously, if at all, in the fall. If the growth is heavy in the autumn a slight grazing will do no harm, but heavy pasturing in the spring will lessen the vitality of the plant and thus tend to produce a light yield of seed.

FIG. 3.—Field of meadow fescue in shock, showing the bands at the top.

The principal shipping points in Kansas for meadow fescue seed have been in the past at Gardner, Wellsville, Olathe, and Springhill in Johnson County; Overbrook in Osage County; Reading in Lyon County; Madison and Hamilton in Greenwood County; Fredonia and Lafontaine in Wilson County; and Marysville in Marshall

County. Some seed has been shipped from Lockwood and Nevada, Mo., but the whole State of Missouri has never furnished more than five carloads in any one year.

Hay.—Seed production has so overshadowed all other interests in meadow fescue growing that only a small quantity of hay is put on the market, very little of the grass being cut at the right stage of growth to make prime hay. For this reason there is no established price for the hay in cities. Several stockmen who are growing meadow fescue for hay exclusively claim that although the hay is somewhat stemmy and inclined to be slightly laxative, it is an excellent fat producer, and when mixed with timothy and clover improves the value of these as hay for general feeding purposes.

A crop of hay is sometimes cut after the seed harvest, but this is possible only when the harvest is followed by rains and the meadow is young and vigorous. A crop of this kind is largely leaves, and if mixed with clover makes a splendid feed, fully equal to timothy and clover for most animals. It can hardly be recommended for driving horses, however, on account of its laxative effect. Meadow fescue hay is almost as palatable as timothy, and chemical analyses indicate that its nutritive value is even higher. When used exclusively as a hay crop it is cut just as it is coming into bloom, about June 20 to 25. The yield is usually 1 to 1½ tons per acre, which, however, can be increased to 2 and even 3 tons by the application of barnyard manure. The aftermath is usually good, much stronger than timothy, and furnishes succulent pasturage until well into the winter.

Pasture.—For pasture, especially in mixtures, meadow fescue is one of the best grasses yet tried throughout eastern Kansas and southeastern Nebraska. Stockmen find it most valuable as an early and a late pasture. It is ready for the cattle in this region usually by the middle of March or the first of April, and it is pastured at this time for almost two months, when the stock are removed to native pastures. By the first of August the aftermath is beginning to show a good growth. In most cases, however, there is little rain during August, and it is September 15 or later before the aftermath is heavy enough to stand pasturing. Meadow fescue continues to grow, however, through the cool weather of fall and early winter, and even after snowfall furnishes considerable green feed if not too heavily pastured during the summer months. For this reason it is valuable to supplement native pastures during October and the early part of November before the cattle are put in the feed yard. It is superior to Kentucky bluegrass during the hot summer months, but is not equal to the native bluestem pastures for that part of the year. Meadow fescue, although it has no rootstocks, is not inclined to become bunchy or tussocky when pastured, as does orchard grass.

Meadow fescue is quite valuable for dairy cows, but its principal point of excellence is as pasture for fattening cattle. It has a splendid reputation among the feeders of eastern Kansas and southeastern Nebraska. Many claim for it a relatively high value as hog pasture, but it is only in localities where a shallow soil and the presence of hardpan prohibit the successful culture of alfalfa that it is used for this purpose. Brome-grass also outranks it in this respect, being evidently preferred by hogs when the two grasses are growing together.

The length of time during which a meadow will produce hay and pasture profitably depends altogether on its treatment. Meadows of this grass when treated with barnyard manure have remained productive from twelve to seventeen years. The most progressive farmers, however, make use of meadow fescue in a rotation, allowing a field to remain in meadow from three to six years only. For permanent pastures there is great advantage in mowing the weeds once or twice a year and applying a top-dressing of manure. The manure should always be spread with a manure spreader and only a light application given. For some time after this application the pasture will be useless, so that it is best to apply it to only one-half of the pasture land at a time, covering the halves in alternate years.

Mixtures with other grasses.—Meadow fescue is now used throughout all the region indicated on the map (fig. 1) as a prominent constituent in pasture mixtures and to a small extent for hay meadows. These mixtures of course should vary according to the latitude. In Nebraska, for instance, brome-grass, timothy, alfalfa, and red clover are most largely used with meadow fescue; in the central region Kentucky bluegrass and white clover are quite valuable, while farther south orchard grass and alsike clover prevail. To the east in this southern division, tall meadow oat-grass and the rye-grasses are added with good results, and on wet soils redtop is extremely valuable. In the western part of this region a considerable number of farmers are using alfalfa in connection with the grasses for pasture with splendid results, especially in increasing the amount of pasturage. Very little trouble is experienced from bloating when the pasture has less than 50 per cent of alfalfa.

On heavy soils the meadow fescue is likely to prove more than an equal in competition with the other grasses, but in localities especially suited to Kentucky bluegrass or brome-grass, as the case may be, meadow fescue is overcome and gradually crowded out. Its special value arises from its characteristic of coming surely and quickly from seed, thus occupying the ground to the exclusion of weeds and furnishing forage while the weaker grasses are getting started.

Rotative value of meadow fescue.—The most sensible and profitable system of rotation for meadow fescue when being grown for seed production was found in use on a farm near Wellsville, Kans. On this farm meadow fescue is valued very highly as a soil renovator, the owner believing that its effect on corn is nearly equal to that of clover. His fields are arranged to accommodate meadow fescue three years, followed by two years of corn, then one year in small grain. This six-year rotation carries the meadow fescue through its period of greatest production and changes often enough to allow for the production of considerable corn, which is necessary in the feeding operations of this region and as a money crop. In the cornfields under this system the division between the first and second year from meadow could be distinctly noted by the darker color of the foliage and the greater vigor of the stalks. Whether or not any regular rotative system is followed, corn is generally the crop used to succeed meadow fescue.

Breaking up a meadow.—The breaking up of a meadow is generally carried on in the fall, as this allows the sod to decay and mellow before planting time in the spring. In the spring the field is either back-set or disked up thoroughly, when it can be planted or listed as desired. The sod of meadow fescue, although a trifle tougher than timothy, is not difficult to get into condition, never giving the trouble that brome-grass does in the Dakotas by resodding the field. Farmers declare that meadow fescue sod disintegrates so quickly that even the first cultivation of the corn is not difficult. All growers unite in declaring it a very useful crop for improving soil texture.

ENEMIES OF MEADOW FESCUE.

Rust.—Four or five years ago the oat rust (*Puccinia coronata*) began to be destructive in the fescue fields. It does not appear usually in any prominence until after harvest. Then, if the season is wet, the aftermath will be so badly affected that not only is the fall pasture ruined, but the functions of the plants are so hindered that they pass through the winter in a weakened state, and in the spring, instead of stooling out, the grass sends up few culms, and consequently the seed harvest is decreased.

The exact amount of decrease attributable to the rust can not be determined, but there is no doubt that the injury has been severe for the past four years, owing largely to the unusual amount of rainfall during the summer months. In the past, prior to the appearance of the rust, a second cutting of hay was expected in a majority of years; now it is looked upon as quite unusual. The aftermath in many fields was quite badly affected in 1907, the old meadows being the ones most subject to attack. In these the value of the pasture was very small.

Weeds.—The most troublesome weeds in the fescue meadows are whitetop (*Erigeron ramosus*), common cheat (*Bromus secalinus*), and Japan cheat (*B. japonicus* Thumb., *B. patulus* Mert. and Koch.), buckhorn, broad plantain, and dock. Of these the first two are by far the most serious. Cheat (*B. secalinus*) has always caused trouble in meadow fescue production on account of the very close resemblance of its seeds to those of the fescue. A number of farmers who have purchased and planted meadow fescue seed have found their fields to be largely cheat the following year. This can be attributed to some extent to the ability of the cheat to germinate almost perfectly even under adverse conditions. The principal cause, however, lies in the carelessness of seedsmen when purchasing their supply of fescue seed, it being nearly impossible to separate cheat (*Bromus secalinus*) seed from that of meadow fescue when once they are mixed (see figs. 4 and 5). This difficulty is overcome in the fescue region to a great extent by the farmer buying seed from his neighbor which was produced in a field he knows to be practically free from cheat.

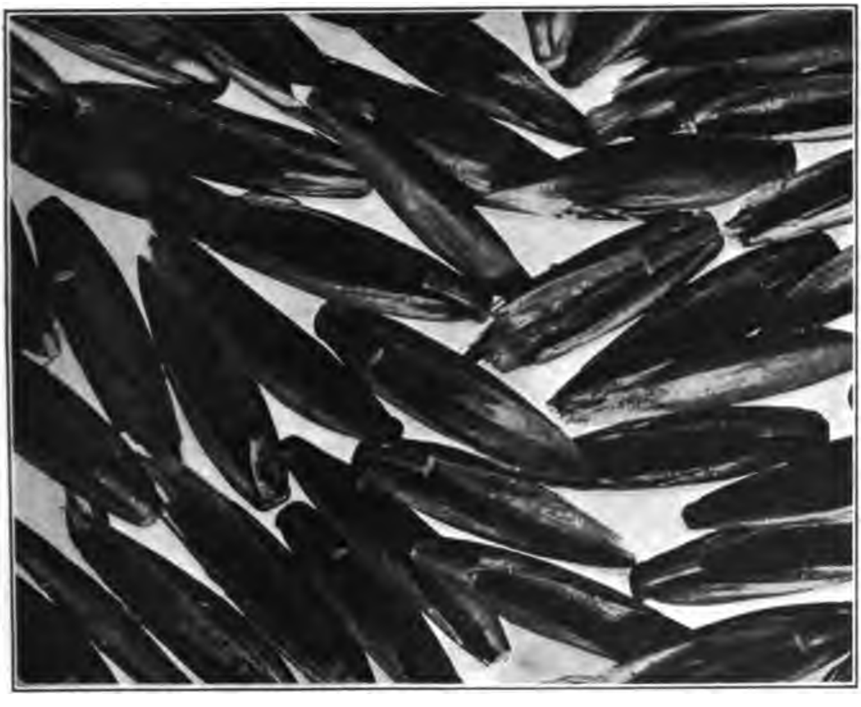

FIG. 4.—Meadow fescue seed. Magnified nine diameters.

There has lately appeared in a few fields another form of cheat. This is a slender, slightly recumbent, pubescent species naturalized from Europe (*Bromus japonicus*). It was noted on several farms in

Johnson County, Kans., and has become quite well established along hedgerows and in fence corners. It seems to be a particularly aggressive species, and is feared by those who know it much more than *Bromus secalinus*, which appears to prefer the cultivated ground.

Whitetop (*Erigeron ramosus*) is troublesome only at irregular intervals. A number of fields visited during 1907 had much the appearance of fields of daisies. Meadows as badly infested as this were rare, but a great many contained enough of the weed to insure its further dissemination. It will be difficult to check its distribution over the fescue region, especially in meadows where no definite rotation is practiced. The new fields are always the cleanest and a short rotation tends to rid the fields of plantain and dock as well as whitetop.

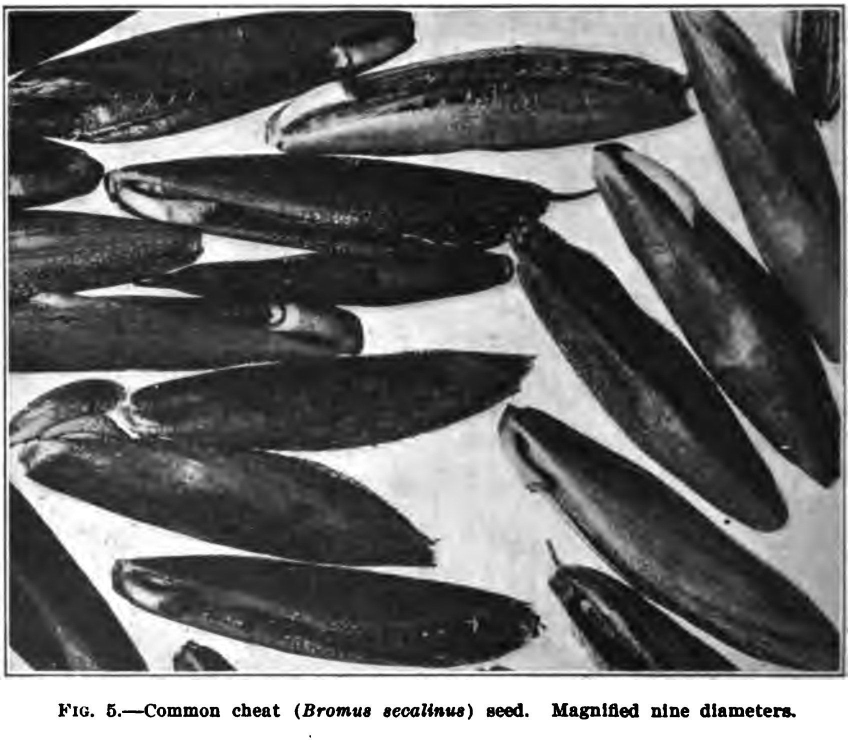

FIG. 5.—Common cheat (*Bromus secalinus*) seed. Magnified nine diameters.

MEADOW FESCUE IN THE EAST.

Reports from the agricultural experiment stations of Kentucky, Tennessee, Alabama, and North Carolina indicate that meadow fescue is a valuable grass in each of these States. Its strong points are enumerated by writers as drought resistance, frost resistance, and early spring and late fall pasturage. Where grown in New York the results have been quite satisfactory, and a trial by farmers in Virginia has resulted in the conclusion that meadow fescue is valuable for hay and pasturage, furnishing earlier grazing than any other grass tried.

A thorough trial of meadow fescue at the Government experimental farm at Arlington, Va., develops the fact that on the poor, stiff, clay soil there a stand of meadow fescue can be obtained easily, the vitality of the seed being equal to that of any of the different grasses tried. This ability to come up early and strong in the spring is of great importance for pasture purposes, especially where weeds are numerous, as they are throughout the East.

Fifteen different mixtures of perennial grasses were tried at the Arlington Experimental Farm to determine the best combination for hay and for pasture. In all of these meadow fescue proved an exceedingly valuable constituent, improving the plot in appearance and in amount of forage produced. The plot giving the best results was a very complex mixture, containing orchard grass, timothy, brome-grass, redtop, English and Italian rye-grasses, Kentucky bluegrass, meadow fescue, tall meadow oat-grass, and red, white, and alsike clover. This plot early in the spring (March 16) showed splendid vigor, the meadow fescue and rye-grasses rooting strongly enough to prevent the upheaval by frost of any of the grasses in the plot; these grasses not only resist upheaval themselves but hold the other grasses in by their strong root systems. This plot was cut July 1 and yielded at the rate of 3½ tons per acre.

Another plot which did especially well and showed the value of the meadow fescue consisted of English and Italian rye-grasses and meadow fescue. This plot was one of the earliest and best in the section, yielding at the rate of 2½ tons to the acre.

These yields are not indicative of the exact value of meadow fescue as a hay grass when used alone, since the yield of plots containing meadow fescue only was low compared to that of plots on which standard grasses were grown.

The different plots of pure grasses (each one-twentieth of an acre in extent) gave yields of hay as follows:

	Pounds.
Meadow fescue	154
Redtop	160
Tall oat-grass	186
Timothy	180
Italian rye-grass	160
Perennial rye-grass	140
Orchard grass	144

It would appear from the yields here given that meadow fescue is not equal to timothy in a region where the latter does well, and the lack of leaves on the culms of meadow fescue would limit its use for hay purposes in any locality. The aftermath, however, on the plots containing meadow fescue was invariably stronger and more succulent than that on plots of other grasses, and the heavy frosts of late fall did not injure it. This ability to produce a large amount of fall pasturage after being cut for hay compensates to some extent for the deficiency of meadow fescue in yield of hay.

The behavior of meadow fescue at the Arlington Experimental Farm leads the writer to believe that in the East it is a most valuable constituent for any pasture mixture, and that, in fact, it should be for many localities the predominating member of the group.

PRESENT IMPORTANCE AND FUTURE OF MEADOW FESCUE.

There is no doubt that the acreage of meadow fescue in eastern Kansas has decreased steadily since 1903. A careful investigator who has canvassed the situation thoroughly in buying seed for a firm in Chicago, Ill., claims that at least 40 per cent of the old meadow fescue fields of Johnson County have been plowed up in the last two years. The exact status of the industry in Gardner Township is shown by the assessors' returns, which state that there were 2,200 acres in meadow fescue in 1906 as against 1,000 in 1907. This township is the home of the meadow fescue seed industry, producing more seed than any other locality in the State. Results here are an index to conditions in all other localities, the same decrease being noticeable in Osage, Wilson, Marshall, and Greenwood counties. The cause of this decrease has already been explained in the discussion of the rust and the seed prices.

At the present value of the land in eastern Kansas a yield of 10 to 15 bushels of seed per acre should be accompanied by a price of 5 or 6 cents a pound to make its production profitable from a seed standpoint. Even then, meadow fescue would take precedence over wheat and other grains only because of its perennial habit in connection with the production of seed. It has superseded alfalfa in northeastern Kansas because it has been found difficult to grow the latter there on account of the heavy rainfall and shallow soil, much of the fescue land being underlaid by hardpan.

The future expansion of the area devoted to meadow fescue culture will depend on its use in permanent pasture mixtures and in hay meadows east and southeast of its present sphere. While not the very best of hay grasses, it is one of the most valuable of the domesticated grasses for seeding pasture land in any part of the region indicated on the map (fig. 1). It has long been a recognized fact that mixed pastures are as a rule more palatable to stock and that they cover the ground more evenly than any one grass alone, and in mixtures for this purpose meadow fescue is among the best.

TALL FESCUE.

Comparison of tall fescue with meadow fescue.—The opportunity to compare meadow fescue and tall fescue has been limited heretofore on account of the few fields of the latter growing in the United States. During the last two years cooperative experiments in growing tall fescue have been arranged in eastern Kansas for the purpose of comparing it with meadow fescue.

Tall fescue is apparently intermediate in character between meadow fescue and reed fescue. The purely scientific question of their relationship is left for discussion in botanical publications. The fact is quite apparent that tall fescue is at least an agricultural variety, and in field tests it has shown several important differences from meadow fescue. Seedsmen usually list meadow fescue under the technical name of *Festuca pratensis* and tall fescue under the name of *Festuca elatior*. This usage is well fixed agriculturally, but the two varieties do not represent distinct botanical species or subspecies.

Seed habits of tall fescue.—Tall fescue (see figs. 6 and 7) has an undesirable habit of ripening its seed very unevenly on the panicle, causing it to shatter badly. Growers are forced to harvest their tall fescue while the seed stalk is still quite green in order to save any considerable portion of the seed. This fault very likely accounts for the ordinarily low germination of the seed, and coupled with the fact that tall fescue sends up very few culms makes the yield light. From 3 to 7 bushels per acre were harvested last season in the same fields which gave a yield of from 12 to 18 bushels of meadow fescue seed. This was largely due to the fact that a clump of the latter grass possessed from two to three times as many seed stalks as one of the tall fescue. The growers complained, also, that nearly half of the seed shattered out before it could be taken to the machine.

The results of experiments at Pullman, Wash., have seemed to indicate that in the district around Pullman seed of tall fescue can be produced very profitably. Plots consisting of from two to three square rods yielded in cultivated rows at the rate of 24 bushels per acre. These rows were about 18 inches apart and were cultivated with a wheel hoe. Where broadcasted, about half of this quantity of seed was secured. It is worth while to note in this connection, however, that meadow fescue under the same conditions produced at the rate of from 30 to 40 bushels of seed to the acre.

The extremely high price of tall fescue seed makes an ordinary yield quite profitable. Owing to the fact that seed of this grass has been quite scarce, the price has ranged in the United States from 20 to 30 cents a pound. It is valued very highly in England, and as the true tall fescue is much desired for seeding meadows and pastures there, England may provide a considerable market for American-grown seed when the fact is established that pure seed is being grown in the United States.

Rust resistance of tall fescue.—The foliage of tall fescue is quite abundant at the base of the plant, but the seed stalks as a rule are rather bare. Growing as it has been in the same fields with meadow fescue for the last two years in Johnson County, Kans., where the rust has been quite destructive, there has not yet appeared the slightest sign of rust on tall fescue.

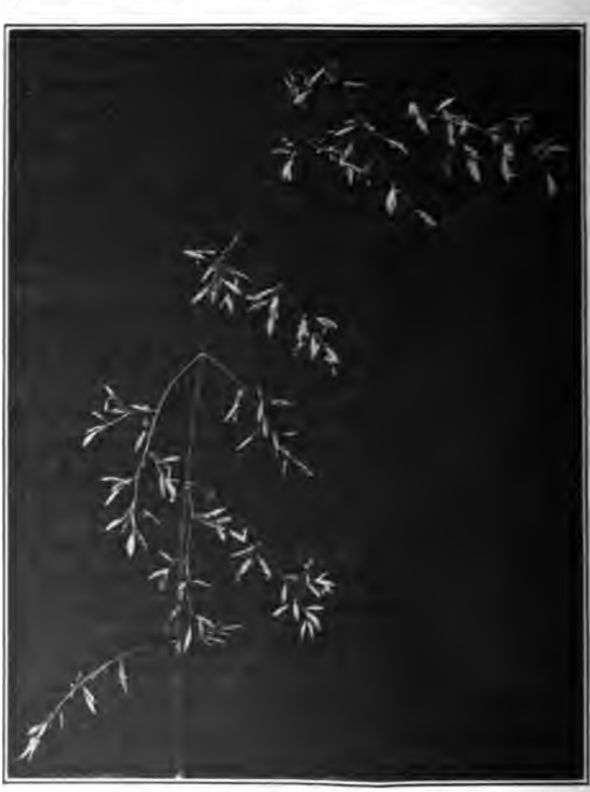

FIG. 6.—Panicle of tall fescue.

Inoculation tests in the greenhouse have demonstrated the fact that it is possible to artificially inoculate tall fescue with the rust prevalent on meadow fescue. Its resistance, therefore, may be due largely to its greater vigor. If the destructiveness of the rust continues to increase in the meadow fescue fields of eastern Kansas, growers will necessarily be obliged to substitute some grass which is not so badly affected by it. Tall fescue gives most promise of filling this want. Another advantage which arises largely from its rust resistance is the strong aftermath that tall fescue always produces after the seed harvest. One grower near Edgerton, Kans., cut very nearly a ton of hay per acre from his tall fescue field two weeks after the seed harvest. Others secured an aftermath fully equal to this.

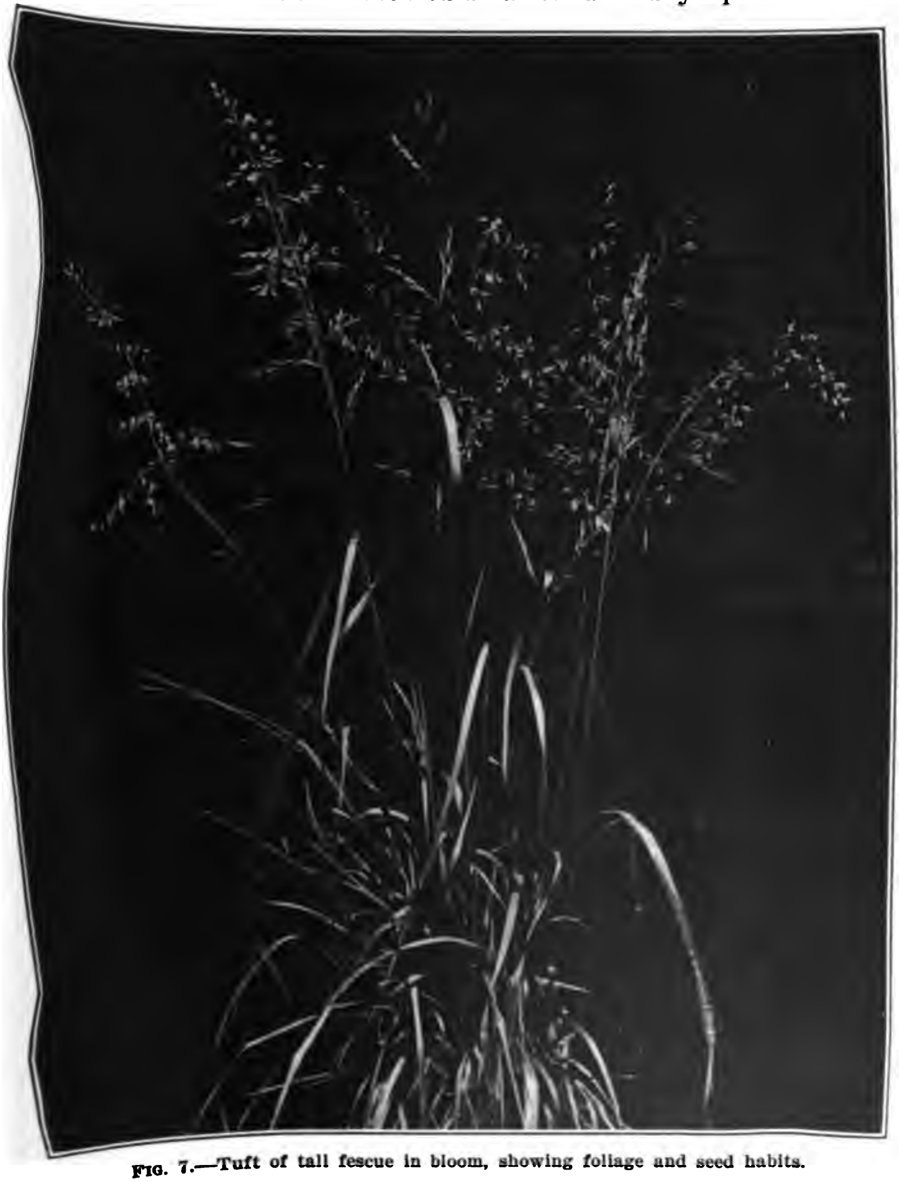

FIG. 7.—Tuft of tall fescue in bloom, showing foliage and seed habits.

Importance of tall fescue.—It would appear that tall fescue may become of some importance in this part of Kansas, and if the seed can be produced cheaply enough it will largely replace meadow fescue in pasture and meadow mixtures for the East-Central States, because it invariably makes a more vigorous growth of foliage.

SUMMARY.

(1) Meadow fescue is largely called "English bluegrass," but that name should be discarded for the correct one.

(2) Meadow fescue is most important in eastern Kansas and southeastern Nebraska.

(3) This grass should be utilized more largely in the pasture mixtures of the East-Central States.

(4) The peculiar advantages of meadow fescue for use in mixtures are its certain and strong germination from seed, its palatability, and its ability to endure trampling and to thrive in wet, "gumbo" spots.

(5) The production of meadow fescue seed has been quite an important industry over a considerable section in eastern Kansas, but the area devoted to it is decreasing on account of the prevalence of rust and the uncertainty as to price of seed.

(6) The worst impurity in commercial meadow fescue seed is ordinary cheat (*Bromus secalinus*), which is quite common in the meadow fescue fields of Kansas.

(7) A substitute for meadow fescue if the rust makes its production unprofitable can be found in tall fescue, which appears to be rust resistant.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
73. Experiment Station Work—IV. Pp. 32.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
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97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
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103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 31.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
110. Rice Culture in the United States. Pp. 28.
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119. Experiment Station Work—XV. Pp. 30.
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124. Experiment Station Work—XVII. Pp. 32.
126. Practical Suggestions for Farm Buildings. Pp. 48.
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128. Eggs and Their Uses as Food. Pp. 40.
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132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
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187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
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192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
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200. Turkeys. Pp. 40.
201 Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 45.
206. Milk Fever and Its Treatment. Pp. 16.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
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220. Tomatoes. Pp. 32.
221. Fungous Diseases of the Cranberry. Pp. 16.
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223. Miscellaneous Cotton Insects in Texas. Pp. 24.
224. Canadian Field Peas. Pp. 16.
225. Experiment Station Work—XXIX. Pp. 32.
227. Experiment Station Work—XXX. Pp. 32.
228. Forest Planting and Farm Management. Pp. 22.
229. The Production of Good Seed Corn. Pp. 24.
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233. Experiment Station Work—XXXI. Pp. 32.
234. The Guinea Fowl. Pp. 24.
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245. Renovation of Worn-out Soils. Pp. 16.
246. Saccharine Sorghums for Forage. Pp. 37.
248. The Lawn. Pp. 20.
249. Cereal Breakfast Foods. Pp. 36.
250. The Prevention of Wheat Smut and Loose Smut of Oats. Pp. 16.
251. Experiment Station Work—XXXIV. Pp. 32.
252. Maple Sugar and Sirup. Pp. 36.
253. The Germination of Seed Corn. Pp. 16.
254. Cucumbers. Pp. 30.
255. The Home Vegetable Garden. Pp. 47.
256. Preparation of Vegetables for the Table. Pp. 48.
257. Soil Fertility. Pp. 39.
258. Texas or Tick Fever and Its Prevention. Pp. 45.
259. Experiment Station Work—XXXV. Pp. 32.
260. Seed of Red Clover and Its Impurities. Pp. 24.
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274. Flax Culture. Pp. 36.
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278. Leguminous Crops for Green Manuring. Pp. 27.
279. A Method of Eradicating Johnson Grass. Pp. 16.
280. A Profitable Tenant Dairy Farm. Pp. 16.
281. Experiment Station Work—XL. Pp. 32.
282. Celery. Pp. 36.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks. Pp. 42.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Pp. 48.
285. The Advantage of Planting Heavy Cotton Seed. Pp. 16.
286. Comparative Value of Whole Cotton Seed and Cotton-seed Meal in Fertilizing Cotton. Pp. 14.
287. Poultry Management. Pp. 48.
288. Nonsaccharine Sorghums. Pp. 28.
289. Beans. Pp. 28.
290. The Cotton Bollworm. Pp. 32.
291. Evaporation of Apples. Pp. 38.
292. Cost of Filling Silos. Pp. 15.
293. Use of Fruit as Food. Pp. 38.
294. Farm Practice in the Columbia Basin Uplands. Pp. 30.
295. Potatoes and Other Root Crops as Food. Pp. 45.
296. Experiment Station Work—XLI. Pp. 32.
298. Food Value of Corn and Corn Products. Pp. 40.
299. Diversified Farming Under the Plantation System. Pp. 14.
300. Some Important Grasses and Forage Plants for the Gulf Coast Region. Pp. 15.
301. Home-grown Tea. Pp. 16.
302. Sea Island Cotton: Its Culture, Improvement, and Diseases. Pp. 48.
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305. Experiment Station Work—XLII. Pp. 32.
306. Dodder in Relation to Farm Seeds. Pp. 27.
307. Roselle: Its Culture and Uses. Pp. 16.
309. Experiment Station Work—XLIII. Pp. 32.
310. A Successful Alabama Diversification Farm. Pp. 24.
311. Sand-clay and Burnt-clay Roads. Pp. 19.
312. A Successful Southern Hay Farm. Pp. 15.
313. Harvesting and Storing Corn. Pp. 29.
314. A Method of Breeding Early Cotton to Escape Boll-weevil Damage. Pp. 28.
315. Progress in Legume Inoculation. Pp. 20.
316. Experiment Station Work—XLIV. Pp. 32.
317. Experiment Station Work—XLV. Pp. 32.
318. Cowpeas. Pp. 28.
319. Demonstration Work in Cooperation with Southern Farmers. Pp. 22.
320. Experiment Station Work—XLVI. Pp. 32.
321. The Use of the Split-log Drag on Earth Roads. Pp. 14.
322. Milo as a Dry-land Grain Crop. Pp. 23.
323. Clover Farming on the Sandy Jack-pine Lands of the North. Pp. 24.
324. Sweet Potatoes. Pp. 39.
325. Small Farms in the Corn Belt. Pp. 29.
326. Building Up a Run-down Cotton Plantation. Pp. 22.
327. The Conservation of Natural Resources. Pp. 12.
328. Silver Fox Farming. Pp. 22.
329. Experiment Station Work—XLVII. Pp. 32.
330. Deer Farming in the United States. Pp. 20.
331. Forage Crops for Hogs in Kansas. Pp. 24.
332. Nuts and Their Uses as Food. Pp. 28.
333. Cotton Wilt. Pp. 24.
334. Experiment Station Work—XLVIII Pp. 32.
335. Harmful and Beneficial Mammals of the Arid Interior. Pp. 31.
336. Game Laws for 1908. Pp. 55.
337. Cropping Systems for New England Dairy Farms. Pp. 24.
338. Macadam Roads. Pp. 39.
339. Alfalfa. Pp. 48.
340. Declaration of Governors for Conservation of Natural Resources. Pp. 8.
341. The Basket Willow. Pp. 43.
342. Experiment Station Work—XLIX. Pp. 32.
343. The Cultivation of Tobacco in Kentucky and Tennessee. Pp. 28.
344. The Boll Weevil Problem with Special Reference to Means of Reducing Damage. Pp. 46.
345. Some Common Disinfectants. Pp. 12.
346. The Computation of Rations for Farm Animals by the Use of Energy Values. Pp. 32.
347. The Repair of Farm Equipment. Pp. 32.
348. Bacteria in Milk. Pp. 24.
349. The Dairy Industry in the South. Pp. 35.
350. The Dehorning of Cattle. Pp. 14.
351. The Tuberculin Test of Cattle for Tuberculosis. Pp. 8.
352. The Nevada Mouse Plague of 1907-8. Pp. 23.
353. Experiment Station Work—L. Pp. 32.
354. Onion Culture. Pp. 36.
355. A Successful Poultry and Dairy Farm. Pp. 40.
356. Peanuts. Pp. 40.
357. Methods of Poultry Management at the Maine Agricultural Experiment Station. Pp. 32.
358. Primer of Forestry. Part II: Practical Forestry. Pp. 48.
359. Canning Vegetables in the Home. Pp. 16.
360. Experiment Station Work—LI. Pp. 32.
361. Meadow Fescue: Its Culture and Uses. Pp. 22.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 362.

CONDITIONS AFFECTING THE VALUE OF MARKET HAY.

BY

HARRY B. McCLURE,
Scientific Assistant, Office of Farm Management,
Bureau of Plant Industry.

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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 26, 1909.

Sir: I have the honor to present herewith a paper entitled "Conditions Affecting the Value of Market Hay," prepared by Mr. Harry B. McClure, Scientific Assistant in the Office of Farm Management, Bureau of Plant Industry, and recommend that it be published as a Farmers' Bulletin.

This paper was prepared from an address delivered before the Fifteenth Annual Convention of the National Hay Association, at Cedar Point, Ohio, July 28–30, 1908, at which meeting resolutions were passed asking that it be published as a bulletin of the Department and distributed among hay producers and feeders.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Factors influencing the hay industry 7
Southern hay trade 9
Tame hay areas of the United States 9
Increase in yield per acre of hay from 1865 to 1905 10
Price of hay for forty years 13
Increasing value of hay lands 13
Fertilizing elements in hay 14
Need of suitable rotations for hay lands 15
Nutritive substances in hay 16
Palatability of hay 17
Digestibility of hay 18
Aroma of hay 19
Grassy and weedy hay 19
Low-grade hay on the market 21
Value of low-grade hay 23
Grades of hay adopted by the National Hay Association 23
Loss caused by stacking hay 25
Value of clover hay 27
Conclusions 27

ILLUSTRATIONS.

Page.
FIG. 1. Map of the United States, showing the production of hay from cultivated and "other tame grasses," as reported by the census of 1900 10
2. Map of the United States, showing the clover-hay area, as reported by the census of 1900 11
3. Diagram showing the average yield per acre of hay, for periods of five years, 1865 to 1905, for the United States and for the ten leading timothy-hay-producing States 12
4. Diagram showing the average farm value per ton of hay on December 1, for periods of five years, 1865 to 1905, for the United States and for the ten leading timothy-hay-producing States 12
5. Diagram showing the relative amounts of digestible protein and carbohydrates in different kinds of hay 17
6. View of a meadow, showing a growth of various grasses and weeds 22
7. Stack of hay, showing deterioration caused by exposure to the weather. 25

B. P. I.—465.

CONDITIONS AFFECTING THE VALUE OF MARKET HAY.

FACTORS INFLUENCING THE HAY INDUSTRY.

At the present time there is considerable confusion and misunderstanding regarding the value of the different kinds and grades of market hay. The producer many times does not know what the market requires in regard to purity, or freedom from volunteer grasses, weeds, etc., and quality, which depends on methods of cutting, curing, and baling. The average feeder often thinks that one kind of hay will answer all feeding purposes and pays a very high price for this kind; consequently, when other kinds which may be more valuable than the standard market hay are sent to the market, they sell at a price which is not very profitable to the producer. This is because the feeder's ideas concerning the feeding value of certain kinds of hay are erroneous. As a result of these misunderstandings both feeder and producer lose money. In order that all concerned in the hay industry, namely, producer, shipper, receiver, and feeder, may each receive his share of profit from the growing, handling, or feeding of hay, it is necessary that they work together in harmony for their mutual benefit. In order to do this and place the hay business on a better foundation, the following points are important:

(1) A better knowledge by the feeder of the feeding value of the different kinds and grades of market hay would be of decided advantage to both feeder and producer. The feeding value of any kind of hay should depend primarily upon the purpose for which it is fed.

(2) Producers in general must realize that it is the feeder who makes the price of hay, and in order to secure the most profit his demands in regard to quality must be met regardless of the producer's opinion. This difference of opinion may be illustrated by the fact that in many sections timothy cut at the end of or even after the blooming period is preferred for feeding on the farm, while the city feeder prefers that which is cut nearer the beginning of the blooming period, and will pay a higher price for this kind.

(3) Growing hay for the market is profitable only when the better grades are secured and when the loss of fertility is no greater than it is in other systems of farming, such as live-stock and dairy farming.

(4) There are a number of bad practices on the producer's part that not only lower the value of the product and thus lessen his profits, but are a source of constant trouble in the disposal of the hay. It is largely on account of such practices that buyers and commission men have been led to seriously consider the problem of how to prevent low-grade hay from going to market. The writer's investigations indicate that at present three-fourths of the low-grade market hay is the result of improper practices, such as allowing the meadow to become grassy and weedy, cutting too late, improper baling, etc., on the part of the producer, and is not caused by rain or unfavorable weather alone, as is generally supposed.

(5) In order to grow timothy hay successfully year after year, the farmer must also grow some legume crop in the rotation for either hay or pasture or as a green-manuring crop, which aids in keeping up the crop-producing power of the land.

Legume hay does not sell well in most markets, primarily because horse feeders have not yet learned the value of clover or alfalfa hay. A proper understanding of the value of these hays on the part of the feeders would be an enormous benefit to the whole hay industry.

The average horse feeder is too liable to think that the hay which is selling for the highest price on the market is the most valuable for all feeding purposes under all conditions. He should change some of his beliefs, especially in regard to some of the kinds of hay.

It is almost impossible to place a definite money value on any kind or grade of hay that will at the same time represent its true value to both producer and feeder. This is because the value may depend on several things, such as the purpose for which it is fed; the place where it is fed, for hay fed on the producer's farm has a different value to him than to the city feeder; the price of the more concentrated footstuffs; and the size of the total crop for the United States.

When considering the profit from hay growing the farmer must consider not only the cost of production, or growing, curing, baling, and marketing, but to a certain extent the value of the fertilizing elements which the crop removes from the soil.

The feeder should value any kind of hay according to the amount of digestible nutrients which it contains, its palatability, and its efficiency in keeping the horse in good condition and enabling it to accomplish the desired amount of work. The southern feeder especially should understand the value of hay, for there are many kinds and grades in southern markets.

SOUTHERN HAY TRADE.

A large quantity of low-grade hay is shipped south every year. This does not mean that the southern markets do not handle the better grades of hay, but that low-grade hay predominates. At present the southern hay dealer is anxious to solve the following questions:

(1) Where can I get more "choice" hay?

The trade is demanding more and more good hay each year, and although feeders are willing to pay a premium for this kind, the dealer is unable to get enough to supply their needs.

(2) What is the relative feeding value or standing of the different kinds of southern hay when compared with timothy hay?

Definite information is needed on this subject, because many farmers in what heretofore has not been a hay-producing section are beginning to grow hay, especially legume hay. They find that it pays to grow legumes for the beneficial effect that this class of plants has on the soil and because legumes when grown for hay are profitable, especially when sold on local markets. Timothy and red clover have not proved successful in the cotton-growing section of the South; therefore it is necessary to grow other kinds of hay to take the place of these. Cowpeas, soy beans, Bermuda grass, vetch, and alfalfa are being sown on increasing areas every year. The South is slowly but surely going into the hay business. It would seem that the time will come when competition in hay growing will force northern shippers to send only the best hay to the South, for the South has certain advantages over the North in producing hay, namely, cheaper land, a longer growing season, and nearness to market, all of which tend to favor the southern producer. At present most of the tame hay is grown in the northeastern part of the United States, and only a small amount in the South or West.

TAME HAY AREAS OF THE UNITED STATES.

According to the last census report, 75 per cent of the tame hay (not including alfalfa, clover, and grain cut green for hay) in the United States is produced in ten States. (See fig. 1.) For all practical purposes, the "other tame grasses" cut for hay referred to in the report may be regarded as timothy, especially in the northeastern part of the United States.

The percentage of the total crop that each State produces is as follows: New York, 14.3; Iowa, 10.7; Pennsylvania, 8.6; Missouri, 7; Illinois, 7; Ohio, 7; Michigan, 6; Wisconsin, 6; Indiana, 4.4; Minnesota, 3.2.

Three-fourths of the clover hay (see fig. 2) was grown in ten States, the percentages being: Indiana, 18.4; Ohio, 12.1; Missouri, 9.5; Illinois, 8.4; Pennsylvania, 6.5; Wisconsin, 5.8; Michigan, 5.1; Iowa, 4.5; Kansas, 4.1; Kentucky, 3.

In 1900, 75 per cent of the alfalfa was grown in six States, as follows: Colorado, 21.2; California, 16; Utah, 13.5; Kansas, 11.5; Idaho, 8.1; Nebraska, 5.2.

In 1865 there were about 21,000,000 tons of hay of all kinds produced; in 1905, 60,000,000 tons, or nearly three times as much. This large increase in amount produced is due almost entirely to greater acreage rather than to increased yield per acre.

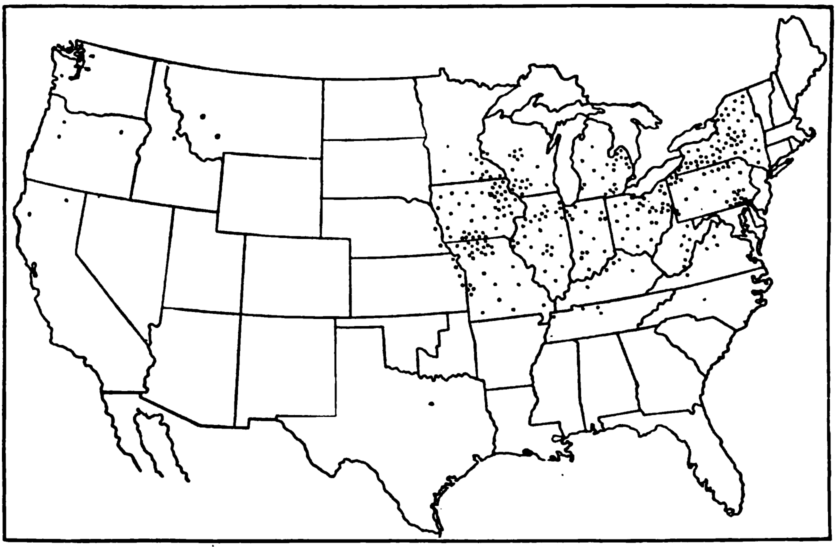

FIG. 1.—Map of the United States, showing the production of hay from cultivated and "other tame grasses," as reported by the census of 1900. Each dot represents 100,000 tons.

INCREASE IN YIELD PER ACRE OF HAY FROM 1865 TO 1905.

The average yield of hay in the United States from 1865 to 1870 was 1.28 tons per acre. This yield was exceeded but three times during the forty years from 1865 to 1905. The average yield for the third five-year period, ending with 1880, was 1.29 tons; that of the seventh five-year period was 1.35 tons; and that for the last five years was 1.47 tons per acre. The average yield for the last period shows an increase of 0.19 ton over that for the first period. and an increase of 0.21 ton over the average yield for forty years, which is 1.26 tons per acre. (See fig. 3.)

The average yield per acre in the ten leading timothy-hay-producing States for forty years varies but little from that for the entire United States. There is a slight difference during the first twenty-five years, when the yield was above that for the United

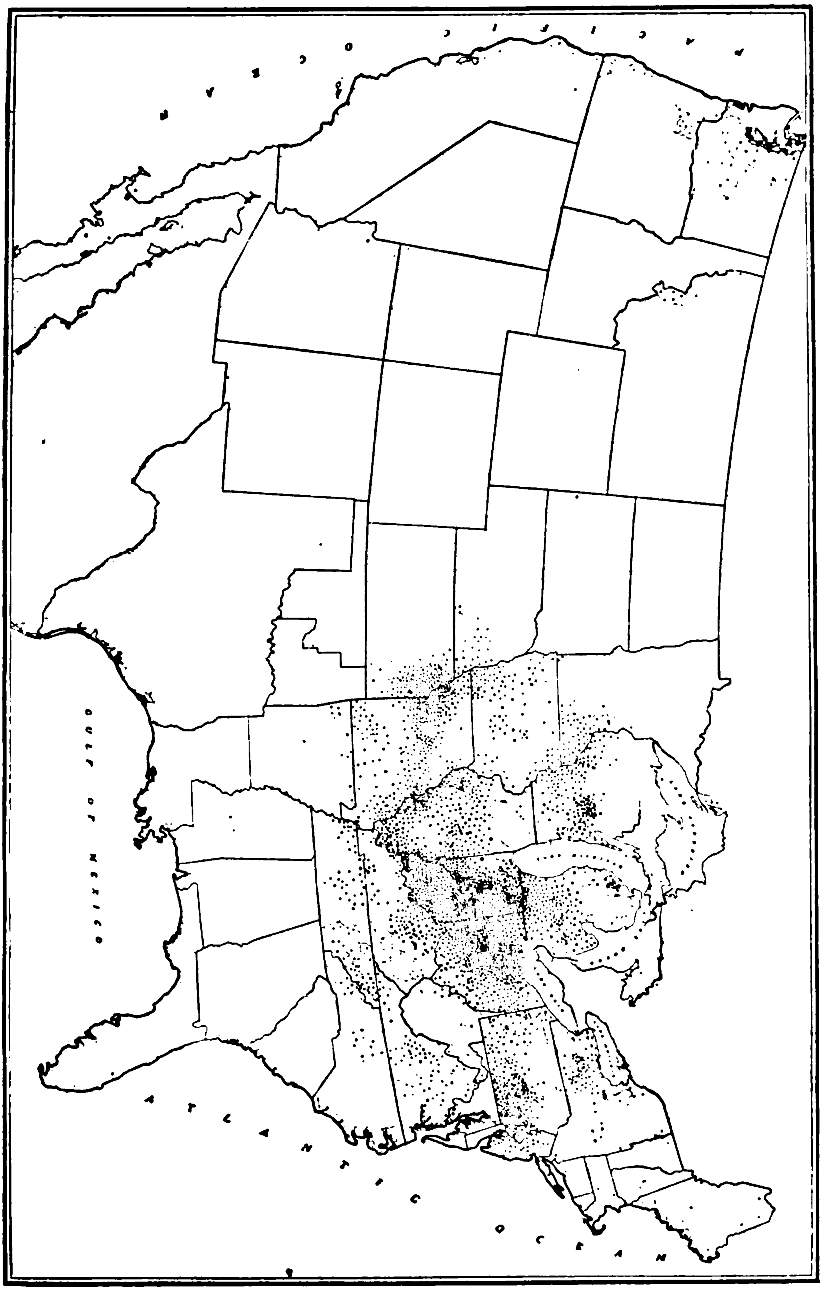

FIG. 2.—Map of the United States, showing the clover-hay area, as reported by the census of 1900. Each dot represents 1,000 acres.

States. The yield during the last fifteen years was nearly the same for both.

The average yield for the ten timothy States for the first five-year period was 1.42 tons per acre. This yield was only equaled once during the entire forty years. This was during the last period, when the yield amounted to 1.46 tons per acre. The yield for the last period shows a gain of 0.04 ton over the yield for the first period, a gain of 0.06 ton over the average for forty years for these States, and a gain of 0.20 ton over the average for forty years for the United States.

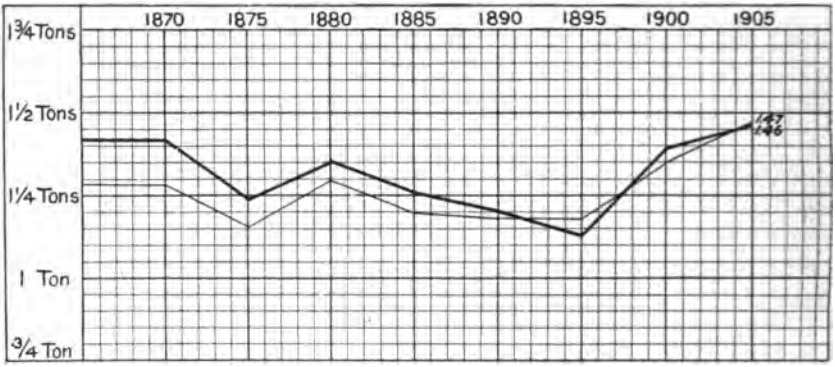

FIG. 3.—Diagram showing the average yield per acre of hay, for periods of five years, 1865 to 1905, for the United States and for the ten leading timothy-hay-producing States. The light line represents the United States as a whole; the heavy line, the ten leading States.

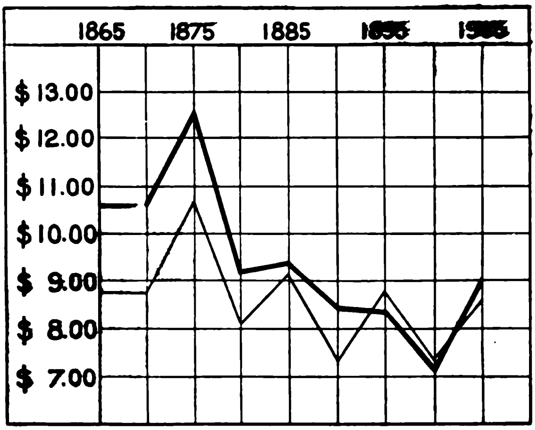

FIG. 4.—Diagram showing the average farm value per ton of hay on December 1, for periods of five years, 1865 to 1905, for the United States and for the ten leading timothy-hay-producing States. The light line represents the United States as a whole; the heavy line, the ten leading States.

After forty years of hay growing the yield per acre for the United States is just a little more than it was in 1870. There are perhaps two reasons for the rising yield during the last ten years of this period—first, within the last ten years better farming has been practiced than during the ten or fifteen years previous; second, the alfalfa area has been greatly increased during the last few years.

Alfalfa yields considerably more per acre than the grasses or clovers, and this tends to raise the average for the United States.

PRICE OF HAY FOR FORTY YEARS.

The price received for hay is the governing factor in determining the profits in growing hay. As shown by figure 4, the average farm value of hay per ton for the first five-year period of the forty years from 1865 to 1905 was $10.61 for the United States and $8.75 for the ten leading timothy-hay-producing States. The highest five-year period for both groups was from 1870 to 1875. These prices have not been equaled since that time, although the farm value since 1900 is higher than it has been since 1885. The average farm value per ton for the forty years was $9.30 for the United States, as compared with $8.58 for the ten timothy States.

INCREASING VALUE OF HAY LANDS.

There is no doubt that during the forty years from 1865 to 1905 farmers have made money when growing the average yield of nearly a ton and a half and selling it for approximately $9 a ton, but within the last few years another factor has entered which has greatly changed the profits on hay growing for the market. This is the increasing value of hay and grain land. The following table[a] shows the increase in value of such land in some of the States in the northeastern section of the United States.

TABLE 1.—*Average real estate value per acre of medium farms with at least two-fifths of income derived from hay and grain, 1900 and 1905.*

State.	Value in 1900.	Value in 1905.	Increase during five years.	
				Per cent.
New York	$40.29	$44.38	$4.09	10.2
Pennsylvania	40.24	43.95	3.71	9.2
Ohio	48.34	58.34	10.00	20.7
Indiana	43.84	57.67	13.83	31.5
Illinois	57.24	78.89	21.65	37.8
Michigan	30.01	36.39	6.38	21.3
Wisconsin	36.44	47.19	10.75	29.5
Minnesota	28.11	35.04	6.93	24.7
Iowa	51.95	66.10	14.15	27.2
Missouri	25.54	36.09	10.55	41.3
North Dakota	11.03	18.82	7.79	70.6
South Dakota	14.54	24.00	9.46	65.1
Nebraska	23.32	36.58	13.26	56.9
Kansas	17.47	27.53	10.06	57.6

The increase in value per acre ranges from 20 to 70 per cent for the States west of Pennsylvania. The increased yield per acre and price per ton during this time is insignificant when compared with the large increase in value of hay land. The point to be remembered is this, that as land increases in value the yield per acre must be increased in like proportion in order to realize the same profit on the investment, provided the price per ton remains the same or nearly so.

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[a] From Bureau of Statistics, Bulletin No. 43, "Changes in Farm Values."

FERTILIZING ELEMENTS IN HAY.

It is time for the producer to figure very closely on the cost of production, especially for the different kinds of hay. Throughout the East and South commercial fertilizers are being used in large quantities, and this practice is gradually extending westward to the great Mississippi Valley States. Every crop takes certain elements of plant food from the soil. It has been found that ordinary soil becomes exhausted first of its supply of available nitrogen, phosphorus, and potassium. It is these three elements which are bought and applied in the form of commercial fertilizers in order to get paying crops. The producer, whether he uses commercial fertilizers or not, should know that when hay is removed from the farm there is a loss of fertilizing elements which are of value to him but not to the city feeder.

There is quite a difference in the amount of plant food contained in different kinds of hay plants. For example, one ton of timothy hay contains, on an average, 20 pounds of nitrogen, 10 pounds of phosphorus, and 28 pounds of potassium.

If bought in the form of a commercial fertilizer, nitrogen is worth 20 cents a pound and the other two elements are valued at 5 cents each per pound. On this basis the fertilizing value of a ton of timothy hay will amount to $5.90, or $6 in round numbers.

One ton of clover hay contains, on an average, 40 pounds of nitrogen, 8 pounds of phosphorus, and 40 pounds of potassium, which makes its fertilizing value amount to $10.40.

According to these figures it would seem that there is less loss of plant food in growing timothy than when clover is grown. However, such is not the case, for clover and all other leguminous plants store up nitrogen in the soil. This class of plants is supplied with a certain kind of bacteria, which live in the tubercles on their roots. These bacteria have the power of taking free nitrogen from the air and making it available as food for the growing plant. Much of the nitrogen thus secured is left in the soil by the decay of the tubercles, roots, stems, and fallen leaves of the legumes, to the great benefit of succeeding crops.

When a ton of clover is removed from the soil, from one-fourth to three-fourths as much nitrogen is left in the roots and crowns and in the fallen leaves and stems left on the ground as is removed in the hay. As a greater part of this nitrogen came from the air, it is perfectly fair and proper when considering the loss of plant food in growing a crop of clover to disregard or deduct it from the total fertilizing value of the hay.

When comparing the loss of fertilizing elements of clover and timothy, there is a difference of about $3 a ton in favor of clover hay. Just how much of this amount should be charged to the hay when considering the profit from selling hay can not be stated definitely, for the kind of soil, system of rotation used, and type of farming play important parts in keeping up the crop-producing power of the soil.

Timothy is often said to be "hard" on the soil. This is because neither timothy nor any other grass can add any plant food to the soil in the manner that the legumes do, but must get all of its food from the soil; and it is therefore much more exhaustive of the available plant food in the soil than clover.

NEED OF SUITABLE ROTATIONS FOR HAY LANDS.

When crops are sold from the farm year after year and no attempt is made toward a systematic rotation, and especially where legumes are not grown, the land in the course of time will become low in available plant food and the yield will be greatly lessened. In fact, on many farms the soil has been so depleted of its fertility that farming is not a paying proposition. It has been found that when land begins to lose its crop-producing power the loss of fertility may be retarded by a proper rotation of crops in which legumes, such as clover, alfalfa, cowpeas, and soy beans, are grown.

Many farmers who in the past have grown nothing but timothy hay for the market are now commencing to grow clover in order to help build up their land. This is why under certain conditions farmers grow kinds of hay which at present are not in greatest demand in the market. This year there is more straight clover and clover-mixed hay sent to the market than usual, and dealers sometimes have difficulty in getting enough timothy hay to supply their trade. It would seem from our observations that there is less timothy hay and more clover being grown each year, and the reasons just given show why the timothy area is decreasing.

Even though the greatest demand is for timothy, the average feeder will not suffer in any way if he is not able to get it, because there are other kinds of hay that will not only take the place of timothy but prove a better and more economical feed. Under ordinary conditions the shipper and the receiver make just as much money by handling one kind of hay as another, so that it is really better for all concerned if there is a smaller quantity of timothy hay produced than formerly. It is necessary, however, for the feeder to understand the feeding value of the different kinds of hay before there can be any great change in the demand for these other kinds, for it is the feeder who makes the price of hay in the market. In order to feed intelligently it is necessary to consider the functions of the nutritive substances.

NUTRITIVE SUBSTANCES IN HAY.

The nutritive substances in hay or feed may be divided into two classes—flesh formers and fuel or energy producing substances. When the proper amount of these two classes of substances is fed the ration is said to be balanced. If an unbalanced ration is fed, as one containing more fuel or energy producing substances than are needed and less flesh-forming material, the ration is partially wasted, and such unwise feeding will not bring as good results as the feeding of the same amount of a balanced ration. Each class of substances has different offices to perform in the body. If not enough flesh-forming substance is fed, the body suffers, because it is absolutely necessary to keep the body in good condition. Thousands of horses are fed all they can eat, yet are poorly nourished because the food contains little except fuel substances.

The flesh-forming substances are used to replace the waste that goes on in all living tissue. Energy-producing substances are used to furnish the energy required for the nervous and muscular activities of the body, and when fed in excess they may to a certain extent be stored up in the form of fat for use later, when needed for either energy or heat.

One of the most important substances in any foodstuff is protein. All nutritive substances which contain nitrogen are classed under the general term of protein. Protein is composed of nitrogen, carbon, hydrogen, oxygen, sulphur, and phosphorus. Protein is the substance which builds up the body. The muscles, tendons, ligaments, connective tissues, skin, hair, hoofs, part of the bone, and in fact every part of the body but fat are made up of protein, together with mineral matter and water.

The next important class of substances is the carbohydrates, which contain carbon, hydrogen, and oxygen, but no nitrogen, sulphur, or phosphorus; they include starch, sugars, etc. These are used for practically the same purpose for which coal or wood is used in the steam engine, namely, to furnish energy and heat.

The third important constituent of hay is its oils. Small quantities of oil are present in all kinds of hay. These oils serve the same purpose as the carbohydrates. A pound of these, however, will furnish two and one-fourth times as much energy or heat as the same quantity of carbohydrates. It can readily be seen, when the chemical analysis of hay is considered, why the price of the different grades or kinds of hay should depend, first, upon the amount of digestible nutrients contained, and, second, upon the purpose for which the hay is fed. If the concentrated feed—i. e., the grain in the ration—lacks protein, then the hay that is high in this substance is more valuable than one which contains little but carbohydrates, and vice versa. There is quite a range in the amount of the different classes of nutrients in the various kinds of hay. (See fig. 5.)

On an average, in 100 pounds of alfalfa hay the digestible protein amounts to 10.58 pounds; in cowpea hay, 10.79 pounds; in alsike clover hay, 8.15 pounds; in red clover hay, 7.38 pounds; in redtop hay, 4.80 pounds; and in timothy hay, 2.89 pounds.

In 100 pounds of redtop hay the digestible carbohydrates amount to 47 pounds; in timothy hay, 43.72 pounds; in alsike clover hay, 41.70 pounds; in alfalfa hay, 37.33 pounds; in cowpea hay, 38.40 pounds; in red clover hay, 36.15 pounds.

When fed for protein, timothy hay ranks last, but when fed for carbohydrates it stands next to redtop, which heads the list. If the total nutrients are considered there are a number of different kinds of hay which are equal, if not superior, to timothy hay for feeding purposes. If cut at the right time and properly cured, Johnson grass and Bermuda grass hay are about equal to timothy in amount of nutriment contained.

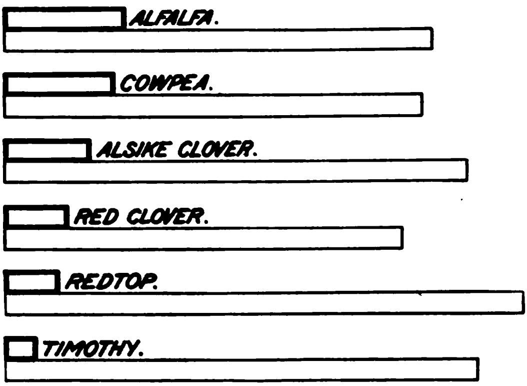

FIG. 5.—Diagram showing the relative amounts of digestible protein and carbohydrates in different kinds of hay. The sections inclosed in light lines represent the carbohydrates; those inclosed in heavy lines, the protein.

PALATABILITY OF HAY.

There is another factor which is very important in determining the feeding value of hay; this is palatability. A hay may be high in nutrients, but if it lacks palatability it is not as valuable a feed as a hay that is poorer in nutrients but is very palatable. Timothy is a very palatable hay, and this is one of the chief reasons why it is standard in most markets. In addition to this, a horse can be fed a large quantity of it and will suffer no ill effects if given a hard drive immediately after having eaten the hay.

Palatability may depend largely on the time the hay is cut and on the method of curing. Redtop may be cited as an example. It is quite generally true that in most markets feeders discriminate severely against redtop whenever it is found mixed in with any other kind of hay. They claim that redtop has no feeding value and that horses will not eat it. The point that the feeder overlooks is that when redtop is cut too late it has a bitter taste, is not palatable, and horses do not relish it, but if cut early it has a sweet taste, is very palatable, and is more nutritious than timothy hay. When buying timothy that contains redtop, feeders should examine it carefully in order to see if the redtop was cut early and properly cured. If it is properly cut and cured it does not lower the quality or feeding value of the timothy, but if found to have been cut late then the bid should be lowered accordingly. It is very seldom that redtop is cut at the proper time, and it is safe to say that perhaps not over one-half of the crop is cut early enough.

Again, there are kinds of hay that when first fed appear to lack palatability, but after the horse has acquired a taste for the hay he does very well on it. On the other hand, some kinds are eaten greedily when fed for the first time. Alfalfa is a hay that is usually very palatable when first fed. In fact, for horses palatability may be an objection in some cases. Many horse feeders have tried alfalfa and are of the opinion that it is of no value for horses.

Upon careful inquiry it has been found that in a large percentage of the cases where serious results were experienced from feeding alfalfa it was on account of ignorance as to the nutritive value of the hay. Unwise use, such as feeding in too large quantities, has led many to become prejudiced against it. If alfalfa hay is properly fed it will be found one of the most valuable feeds, especially for heavy draft horses.

DIGESTIBILITY OF HAY.

The digestibility of the nutrients in hay is another factor that is important in determining its value. If only a small part of the nutrients is digestible, or if a part has been lost by faulty methods of haymaking, then the feeding value is lowered correspondingly. The digestibility may be lowered and the total amount of nutrients lessened by improper curing and handling of the hay.

Plants like clover and alfalfa which have a large amount of nutritious leaves often lose a considerable portion of them on account of poor methods of curing. Alfalfa hay cured under ordinary conditions will lose from 15 to 20 per cent of its leaves. The loss may amount to from 50 to 60 per cent. Alfalfa hay which has lost the greater part of its leaves and consists mostly of stems is often found in the market; consequently, it is only about half as valuable for feeding purposes as when the greater percentage of the leaves is saved.

The Colorado Agricultural Experiment Station found that when alfalfa hay was exposed in the field for fifteen days, during which time it was subjected to three rains, amounting to 1.76 inches, the damaged hay contained but 11 per cent of protein, as compared with 18.7 per cent originally.

In an experiment[a] to determine the loss due to rain, part of a field of grass hay was left in the cock and part in the swath during a rainy spell of eighteen days' duration. At the end of this time the hay in the swath lost 38.8 per cent of its digestible protein, while that in the cock lost only 19.8 per cent. The total nutrients lost in the swath were twice as great as those lost in the cock. This experiment shows that the value of hay cured during unfavorable weather depends a great deal upon the manner or system used in curing hay. Such things as these are of the utmost importance to the feeder. So far as it is possible to determine from an examination of the hay, the price paid should depend on its value for feeding purposes. If this were so it would stimulate the producer to make every effort to cure his hay so as to get the best quality. If he received more for the better grades it would tend to discourage the production of low-grade hay.

AROMA OF HAY.

Although there is no way of determining aroma, this quality of hay adds greatly to its feeding value, or rather its palatability. The writer knows one hay grower who has made quite a reputation on account of the aroma of his hay, and for this reason it outsells that of his neighbors every year. There is a good reason why hay should not lie too long in the swath. When hay lies too long in the sunlight the bleaching which takes place indicates that chemical changes are going on, and these are not of advantage to the hay. Hay that is cured with the least possible exposure to the sun and to dew and rain will have the best aroma.

GRASSY AND WEEDY HAY.

One of the greatest causes of low-grade hay is the presence therein of fine grasses and weeds of various kinds. The rule for determining choice hay is that it must not contain over 5 per cent of other tame and cultivated grasses properly cured, should have a bright natural

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[a] Landwirtschaftliches Wochenblatt für Schleswig-Holstein, 1891, pp. 569–571.

When milk is passed through a centrifugal separator much of the solid impurities remains in the separator slime. A mixture of the skim milk thus purified and the cream which was separated from it is often referred to as "clarified milk."

CARE OF MILK IN THE HOME.

No matter how well milk has been handled up to the time it is delivered to the consumer, it can not be expected to keep well if it is carelessly treated thereafter. It should be poured into pitcher, pan, or other vessel—freshly scalded to remove any bacteria or mold spores—and kept in a cool, clean place free from dirt, flies, etc. New milk should never be mixed with old unless it is to be used at once, as the bacteria in the old milk will of course be added also and the mixed milk will not keep as well as the fresh milk alone. Bacteria are thickest where there is dirt and decay, and milk should therefore be stored only in clean, sweet places. It is safer to keep it covered, to exclude not only dirt and bacteria but also the flavors and odors which it so easily absorbs. If kept at a temperature of 50° F. or less, good milk should remain sweet for twelve hours, at least, after it reaches the consumer, and ordinarily for twenty-four hours or more. Sometimes in very hot weather housekeepers complain that in spite of all precautions it sours quickly, even in the ice box. This is often due to the fact that the air of the ice box, although it seems cold in contrast with the heat outside, is really not cold enough to check the growth of the bacteria; if a thermometer placed inside registers more than 50° F. the fault is almost surely in the temperature of the ice box and not in the milk.

In large cities, where most of the milk comes by morning trains from a considerable distance, it is often impossible to deliver fresh morning's milk in time for breakfast, and that milked the morning before must be given to patrons who insist on an early delivery. They would get their milk from twelve to eighteen hours fresher if they would take it in the afternoon instead.

DIGESTIBILITY OF MILK.

The amount of nourishment which any kind of food furnishes to the body depends, in the first place, on the food ingredients, the protein, fats, and carbohydrates and mineral matters which it contains, and in this respect milk is a well-balanced, nutritious food. But there is another consideration which is brought out by the much-quoted phrase, "We live not upon what we eat but upon what we digest." The nutritive value of food depends not only upon the materials it contains but also upon the amounts of those nutrients which the body can actually utilize—upon its digestibility. As commonly used, the word digestibility refers mainly to the ease and comfort of digestion. This is an important consideration, but does not tell the whole story. As here used the words digestible and digestibility refer to the amount or proportions of the nutritive ingredients of a food material which may by the average healthy digestive organs be made available for the uses of the body. Whether milk is to be classed as a digestible or indigestible food will therefore depend upon the proportions of protein, fats, carbohydrates, and mineral matters which the digestive organs of the average normal person are found to transform into material available for the use of the body.

PROCESS OF DIGESTION.

No one element of the various digestive juices which act upon the food as it passes through the alimentary canal acts upon all classes of nutrients. All are digested separately, though sometimes simultaneously. Since milk contains considerable quantities of each class of nutrients, its digestion will be better understood if we follow the changes in each nutrient separately.

The protein compounds of milk are usually considered to give the most trouble in its digestion, and this is mainly due to the casein. Milk is commonly classed as a liquid food, but this is true only outside of the body; as soon as it reaches the stomach the rennin of the gastric juice precipitates the casein into a curd from which the other ingredients are separated, much as the whey separates from the curd in cheese making. Sometimes the curd tends to become tough and leathery and consequently difficult for the digestive juices to work upon. This is especially marked when for any reason there is considerable calcium phosphate present, and may be partially prevented by adding limewater to the milk. The acid and the pepsin of the gastric juice together work upon the curd and render a small part of it more soluble, but the bulk of the casein is digested in the small intestine by the trypsin of the pancreatic juice. Experiments[a] have shown that casein which has not been curdled by rennin is more completely digested by trypsin than the curdled. Apparently, then, the formation of the curd, especially when tough and leathery, means extra work for the digestive organs.

The albumin of the milk is for the most part easily digested by either the pepsin or the trypsin.

The digestion of fats depends mainly upon getting the globules into such fine size that they may be easily passed through the walls of the intestines. Separating the fat into such tiny globules is called

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[a] Arch. Physiol. [Pflüger] (1902), p. 605.

If hay sells on grade in the country the man who has the poorest hay will receive less than he does now. At present the man who has choice hay receives less than it is worth on the market, and part of the profit which the shipper makes on the good hay must go to make up for the loss on the poor hay. With the present system of buying hay there is not enough difference in the price paid for the better grades in the country; therefore, if the man who has No. 2 hay receives within 50 or 75 cents as much as does his neighbor who has choice hay, he is satisfied and thinks that it is not necessary to take the precautions that his neighbor did in order to get a slight advance in price.

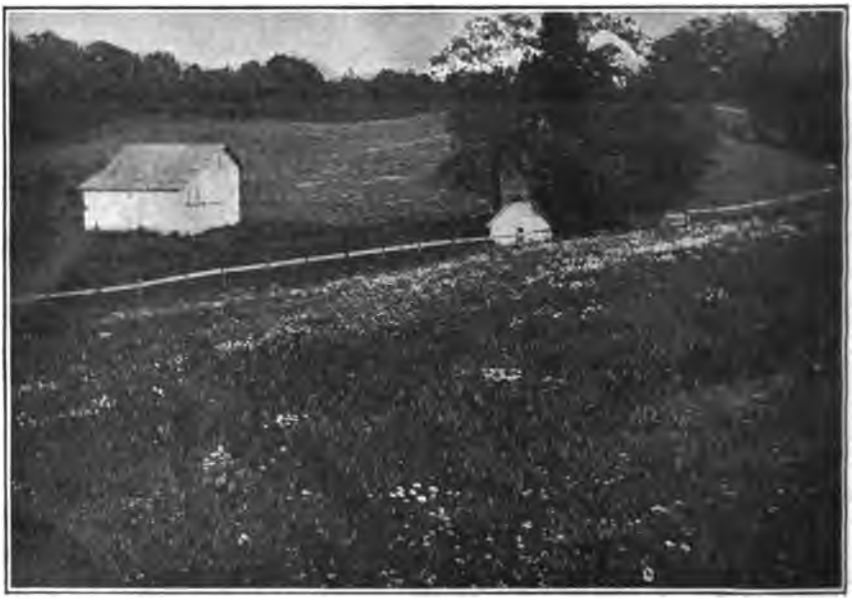


FIG. 6.—View of a meadow, showing a growth of various grasses and weeds. It is impossible to make "choice" hay from a meadow like this.

A firm in Illinois buys hay somewhat according to its grade. It buys a great deal of new hay as soon as it is in good condition to bale, and has a sort of sliding scale, paying the highest price for the hay that is cut early and properly cured. The price is lowered for that which was cut as it approached maturity, depending on the number of days the grass stood after the proper time for cutting. The farmers like this way of selling their hay, and make special efforts to cut it in time to secure the extra profit which the higher price paid at the beginning allows them. This way of selling is successful because farmers have learned the grades of hay and know that they must have choice hay in order to secure top prices.

The causes for hay being graded low, such as its being cut too late, the presence of weeds and fine grasses, and improper methods of curing and baling, can easily be remedied. When intelligent farmers produce low-grade hay it is not on account of the reasons just stated, but because of rains during the haying season. The ordinary methods of curing hay in wet weather usually result in a product that has but little feeding or market value. There are methods of curing hay in wet weather by which a fair grade can be obtained, and its increased value will more than pay for the extra labor involved. The subject of curing is a large one and details of methods can not be given in this paper.

VALUE OF LOW-GRADE HAY.

As long as the present system of buying is in vogue, just so long will the problem of how to dispose of low-grade hay remain unsolved. Therefore, the first thing to do to keep low-grade hay from going to market is to make a readjustment of the price paid for it in the country, so that the different grades will correspond more nearly with those for which the hay is sold in the city. If this system is adopted it will aid materially in decreasing the production of low-grade hay. If the poor hay does not go to market then the question arises, What shall be done with this kind of hay? Low-grade hay is much more valuable to the producer than to anyone else if he will feed it on his farm. This is true, first, because he will save the cost of baling and hauling, and, second, because a ton of timothy hay contains fertilizing elements to the value of about $6. If fed and the manure is well taken care of and returned to the soil at least one-half of the fertilizing elements will become available for the succeeding crops.

Low-grade hay makes a fair roughage for idle work stock and other stock that are being "roughed" through the winter. After getting considerable out of the hay by feeding, there is still about $3 worth of plant food to return to the soil. As a general thing, selling crops from the farm does not represent the highest type of farming, and it is only under certain conditions that it is profitable without lowering or seriously affecting the productivity of the land.

GRADES OF HAY ADOPTED BY THE NATIONAL HAY ASSOCIATION.

In order that the farmer may know definitely what are the different grades of hay, the rules of the National Hay Association, which have been generally adopted in the United States, are quoted herewith.

Choice timothy hay.—Shall be timothy not mixed with over one-twentieth other grasses, properly cured, bright natural color, sound, and well baled.

No. 1 timothy hay.—Shall be timothy with not more than one-eighth mixed with clover or other tame grasses, properly cured, good color, sound, and well baled.

No. 2 timothy hay.—Shall be timothy not good enough for No. 1, not over one-fourth mixed with clover or other tame grasses, fair color, sound, and well baled.

No. 3 timothy hay.—Shall include all hay not good enough for other grades, sound, and well baled.

No-grade hay.—Shall include all hay badly cured, stained, thrashed, or in any way unsound.

Light clover mixed hay.—Shall be timothy mixed with clover, the clover mixture not over one-fourth, properly cured, sound, good color, and well baled.

No. 1 clover mixed hay.—Shall be timothy and clover mixed, with at least one-half timothy, good color, sound, and well baled.

No. 2 clover mixed hay.—Shall be timothy and clover mixed, with at least one-third timothy, reasonably sound and well baled.

No. 1 clover hay.—Shall be medium clover not over one-twentieth other grasses, properly cured, sound, and well baled.

No. 2 clover hay.—Shall be clover, sound, well baled, not good enough for No. 1.

Choice prairie hay.—Shall be upland hay, of bright natural color, well cured, sweet, sound, and may contain 3 per cent of weeds.

No. 1 prairie hay.—Shall be upland, and may contain one-quarter midland, both of good color, well cured, sweet, sound, and may contain 8 per cent of weeds.

No. 2 prairie hay.—Shall be upland of fair color, and may contain one-half midland, both of good color, well cured, sweet, sound, and may contain 12½ per cent of weeds.

No. 3 prairie hay.—Shall include hay not good enough for other grades and not caked.

No. 1 midland hay.—Shall be hay of good color, well cured, sweet, sound, and may contain 3 per cent of weeds.

No. 2 midland hay.—Shall be fair color or slough hay of good color and may contain 12½ per cent of weeds.

Packing hay.—Shall include all wild hay not good enough for other grades and not caked.

No-grade prairie hay.—Shall include all hay not good enough for other grades.

Choice alfalfa.—Shall be reasonably fine, leafy alfalfa of bright green color, properly cured, sound, sweet, and well baled.

No. 1 alfalfa.—Shall be coarse alfalfa or natural color or reasonably fine, leafy alfalfa of good color, and may contain 5 per cent of foreign grasses, must be well baled, sound, and sweet.

No. 2 alfalfa.—Shall include alfalfa somewhat bleached, but of fair color, reasonably leafy, not more than one-eighth foreign grasses, sound, and well baled.

No. 3 alfalfa.—Shall include bleached alfalfa or alfalfa mixed with not to exceed one-fourth foreign grasses, but when mixed must be of fair color, sound, and well baled.

No-grade alfalfa.—Shall include all alfalfa not good enough for other grades, caked, musty, greasy, or thrashed.

In years when the total crop of the United States is an average one there is not much profit per ton to the producer on low-grade hay, and it is only when there is a scarcity that he can dispose of it advantageously. He should get every cent his good hay is worth and not have to help even up the price which is paid for the poor hay that others in his vicinity grow. The only way he can realize the most from his crop is to know its kind or grade, so that he can sell it intelligently.

LOSS CAUSED BY STACKING HAY.

The feeding value of hay is often lowered when it is stacked out in the open. (See fig. 7.) Considerable hay is often entirely spoiled so that it is unfit for feeding. The amount of spoiled and damaged hay depends upon the time the stack stands and upon the method of stacking. In Virginia a 6 to 8 ton stack of timothy hay, after it has gone through the sweat, or in three or four weeks, will have from 300 to 600 pounds of damaged hay. Most of this will be on the top and only a small portion on the sides and the bottom.

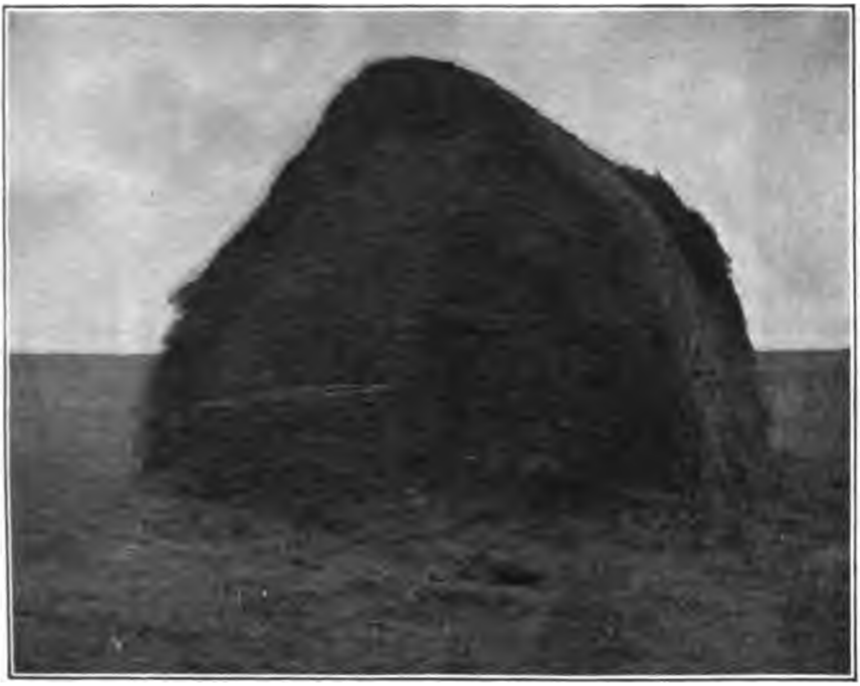


FIG. 7.—Stack of hay, showing deterioration caused by exposure to the weather. The darker portion shows the quantity spoiled in about six months.

The market value of hay is frequently lowered because this stained hay is worked into the bales. It may happen that the spoiled hay will be no more than a couple of handfuls, which amount is really tendency to rise to the surface as do the fat globules of ordinary size. This change in the fat globules is usually accomplished by forcing the milk through capillary tubes and against a resisting surface. The force of impact causes the breaking up of the globules and thus makes a more perfect emulsion of the milk.

SPECIAL INFANT FOODS.

There are numerous patent infant and invalid foods on the market, some of which contain cow's milk as a basis combined with varying amounts of carbohydrates or other constituents, and others which seem to be made of farinaceous materials without milk. In some cases the carbohydrates have apparently been malted before being combined with milk or else malt extract is added during the process of manufacture.

The percentage composition of the two types of infant foods is shown in the table on page 9. The chart on page 37 shows in graphic form how commercial infant food, such as is sold in dry form, in bottles, or in cans, and is made of milk and starch, compares with some other milk products. It is also interesting to compare this product with the data showing the composition of whole milk, skim milk, etc., included in Chart II, p. 30.

Experience has shown that these special milk foods (when they really contain the nutrients of milk) are useful and valuable for infants where it is necessary to resort to some method of artificial feeding, but every one recognizes that where possible mother's milk is the best food for the young child. Too much credence should not be given to the extravagant claims made for some brands of infant foods. The safest course is undoubtedly to follow the advice of a competent physician in selecting the substitute for natural feeding. It is often wiser to use modified cow's milk in preference to these commercial foods, and it can be easily prepared at home under a physician's directions. There are also milk laboratories in many of our large cities and towns where modified milk of all sorts can be procured on prescription.

All babies fed on raw cow's milk are in more or less danger from the undesirable bacteria which it may contain and which cause diarrhea and other serious infant disorders. The question of pasteurizing and sterilizing milk in order to avoid this danger has already been spoken of (p. 16). When raw milk is used, great pains should be taken not only to obtain fresh, clean milk, but also in caring for it scrupulously after it is purchased. It is usually more important that the milk should be pure than that it should be rich in cream, especially as the fat in very creamy milk may be less digestible on account of the size of the fat globules.

NUTRITIVE VALUE OF MILK COMPARED WITH OTHER FOODS.

The value of milk for nourishment is not as generally understood as it should be. Many people think of it, for adults at least, as a beverage rather than a food, and do not realize that a glass of it adds as much to the nutritive value of a meal as a quarter of a loaf of bread or a good slice of beef. A quart of average milk contains the same amount of nutritive ingredients as 0.75 of a pound of beef or 6 ounces of bread. To put it in another way, about one-eighth of the whole weight of the milk, one-third of the beef, and two-thirds of the bread consist of actually nutritive ingredients. The other seven-eighths of the milk and one-third of the bread are water, while the two-thirds of the meat which is not actual nutriment is mainly water, though in part is bone. Chart I shows the average composition of milk, milk products, and some other common food materials. In this chart the percentage amount of refuse, water, protein, fat, carbohydrates, and mineral matter or ash is indicated by shaded portions corresponding to these different constituents, each full division of the lines representing constituents being equivalent to 10 per cent. The heavy black line indicates the number of calories per pound, each full division of this space corresponding to 400 calories.

As compared with the animal foods, it will be noted from this chart that milk contains more carbohydrates and has no refuse. In these two respects it resembles more nearly many of the vegetable foods, such as flour, oatmeal, and the like. The amount of mineral matter is much the same as in the other fresh substances given. There is a larger proportion of water in milk than in most other food materials except very succulent fruits and vegetables, so that a given weight contains less dry matter or nutrients than most foods.

If we wish to compare the food values of the actually nutritive ingredients (the dry matter contained in the edible portion) of different food materials, the calculations may be made on the basis of 1 pound of this water-free edible portion, and the following figures show such a comparison of milk and a few other foods:

Nutrients and energy in 1 pound of the water-free edible portion of several food materials.

Food materials.	Protein.	Fat.	Carbohydrates.	Mineral matter.	Fuel value.
	Pound.	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Whole milk	0.25	0.31	0.39	0.05	2,475
Skim milk (0.3 per cent fat)	.36	.03	.55	.06	1,835
Buttermilk	.33	.06	.53	.08	1,845
Cheese	.39	.52	.03	.06	2,990
Beef, round	.57	.40	....	.03	2,750
Smoked ham	.26	.66	....	.08	3,275
Wheat flour	.13	.01	.85	.01	1,865
Wheat bread	.15	.02	.82	.01	1,865
Potatoes	.10	.01	.85	.04	1,790
Apples	.03	.03	.92	.02	1,885

effects, as there is no danger of the horse overeating, and it is nonlaxative. For these reasons feeders have become used to timothy for feeding to all classes of horses.

(3) The writer's investigations lead him to believe that the clover-hay area is increasing each year and that more straight clover and clover and timothy mixed is sent to the market than formerly. The reasons for this increase in the clover area are, first, that farmers are now beginning to realize more than ever before the value of clover in keeping up the crop-producing power of the soil; and, second, that when clover hay is sold from the farm there is less loss of plant food than when timothy hay is sold. Because of the increased amount of clover-mixed hay sent to the market a new grade called light clover mixed has recently been added to the official grades.

(4) At present clover-mixed hay, especially light clover mixed, brings about the same price as No. 2 timothy. The reason this kind of hay is not in greater demand and does not bring a better price is that feeders do not realize that it contains more nutrients, especially protein, than timothy, and that it will give better returns when fed to horses subject to hard labor, such as heavy hauling and transferring.

(5) Before the value of any kind of hay can be determined, the feeder must know the purpose for which it is to be fed and its adaptability for such a purpose. For example, owners of racing and fancy driving horses feed the choicest of timothy hay, chiefly because it is very palatable, agrees with the horse, and furnishes the required amount of bulk needed in the ration. The purpose in feeding hay to horses doing hard labor is to furnish not only bulk but part of the nutrients, especially protein, required in the ration. For this class of horses good timothy and clover mixed hay will prove more satisfactory than any grade of timothy, being cheaper and containing more nutrients than timothy.

(6) The most important thing in determining the value of hay is palatability, for if it is not relished not enough will be eaten to furnish much nourishment to the animal. When hay is exposed in the field too long in the hot sun or is subject to rain, its palatability will be lessened, which in turn lowers its market and feeding value. Low-grade hay is not as palatable nor does it contain as much nourishment as the better grades.

(7) In general there is little if any profit in growing and selling low-grade hay, especially that made from the grasses, for the loss of fertilizing value or crop-producing power of the land amounts to more than the net profit after the cost of curing, baling, etc., is deducted.

(8) The price of hay land is steadily rising in the tame-hay section, and in order to make a fair profit on the value of the land it will be necessary for the grower to practice the best methods of culture, curing, baling, and selling. Before there can be any material change in the quality of hay sent to the market it will be necessary for farmers to learn the grades of hay, for it is impossible to grow choice hay if the producer does not know what constitutes this grade.

(9) A proper understanding of the feeding value of market hay and market requirements is greatly to be desired on the part of everyone engaged in the growing, handling, and feeding of hay.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
73. Experiment Station Work—IV. Pp. 32.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 31.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
110. Rice Culture in the United States. Pp. 28.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
152. Scabies of Cattle. Pp. 32.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
167. Cassava. Pp. 32.
169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
185. Beautifying the Home Grounds. Pp. 24.
186. Experiment Station Work—XXIII. Pp. 32.
187. Drainage of Farm Lands. Pp. 38.
188. Weeds Used in Medicine. Pp. 45.
190. Experiment Station Work—XXIV. Pp. 32.
192. Barnyard Manure. Pp. 32.
193. Experiment Station Work—XXV. Pp. 32.
194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
197. Importation of Game Birds and Eggs for Propagation. Pp. 30.
198. Strawberries. Pp. 24.
199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201 Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 45.
206. Milk Fever and Its Treatment. Pp. 16.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
213. Raspberries. Pp. 38.
217. Essential Steps in Securing an Early Crop of Cotton. Pp. 16.
218. The School Garden. Pp. 40.
219. Lessons from the Grain Rust Epidemic of 1904. Pp. 24.

The following lunch, such as might be obtained in a restaurant or lunch room, will serve for the purpose of comparison:

Estimated cost and nutrients of a restaurant lunch.

Food materials.	Amount.	Estimated cost.	Protein.	Fuel value.
	Ounces.	*Cents.*	*Pound.*	*Calories.*
Soup	8.0		0.01	75
Beef	2.0		.02	275
Potatoes	2.0			100
Turnips	1.0			15
Bread	3.0		.02	225
Butter	.5			100
Coffee:				
Milk	1.0			20
Sugar	.5			55
Total		15-20	.05	865

It will thus be seen that the 15-cent lunch, containing nine different food materials, would not have any greater nutritive value than the 5-cent lunch of bread and skim milk; though it contained a few calories more of energy, it would yield only about half as much protein.

The idea that only whole milk is fit to use, which is rather erroneously held by housewives, is perhaps ascribable to the esteem in which cream is held as an ingredient of "rich food," and may lead to quite needless waste or expenditure. For growing children, who need large quantities of protein and carbohydrates, 2 quarts of skim milk would supply more of these constituents and more ash than 1 quart of whole milk, and it has already been suggested that fresh skim milk of good quality, sold under its real name and at a reasonable price, is preferable to suspicious whole milk. Many families who are in the habit of drinking whole milk and buying cream would doubtless be quite as well off if the top of the milk, say 2 or 3 inches in a quart bottle, were poured into the cream instead of the milk pitcher; the milk ought still to be far from thin and blue, and there would be a marked saving in the cost of cream. On the farm skim milk is often considered fit only for the pigs; but it really may be used in cookery, etc., as a useful and economical food, though it is only fair to say that on a farm milk is often so abundant that the fresh whole milk will naturally be selected for culinary and table purposes. The fresh whole milk seems to most persons more tempting as a beverage, perhaps, than older skim milk, though this is a matter largely of cultivation and habit; but if no one cares to drink it the skim milk can always be used in cooking, as will be discussed in a later section, a fact of more importance from the standpoint of economy in families where milk is purchased than in those where it is produced.

COST OF NUTRIENTS IN WHOLE MILK AND SKIM MILK.

Just as the nutritive value of a given food depends not simply on its chemical composition but on its proportion of digestible nutrients, so its real cheapness or dearness depends not on the price per quart or per pound, but on the amount of digestible nutrients which a given sum will purchase. Milk is economical in the sense that it contains no refuse, such as the bone and gristle of meat, the shells of eggs, and the skins and seeds of vegetables. Moreover, the proportion of its nutrients which can be digested and utilized by the body is, under ordinary circumstances, larger than that from most food materials. The thing which might make milk expensive is its diluteness—that is, the large amount of water which it contains in proportion to its solid matter.

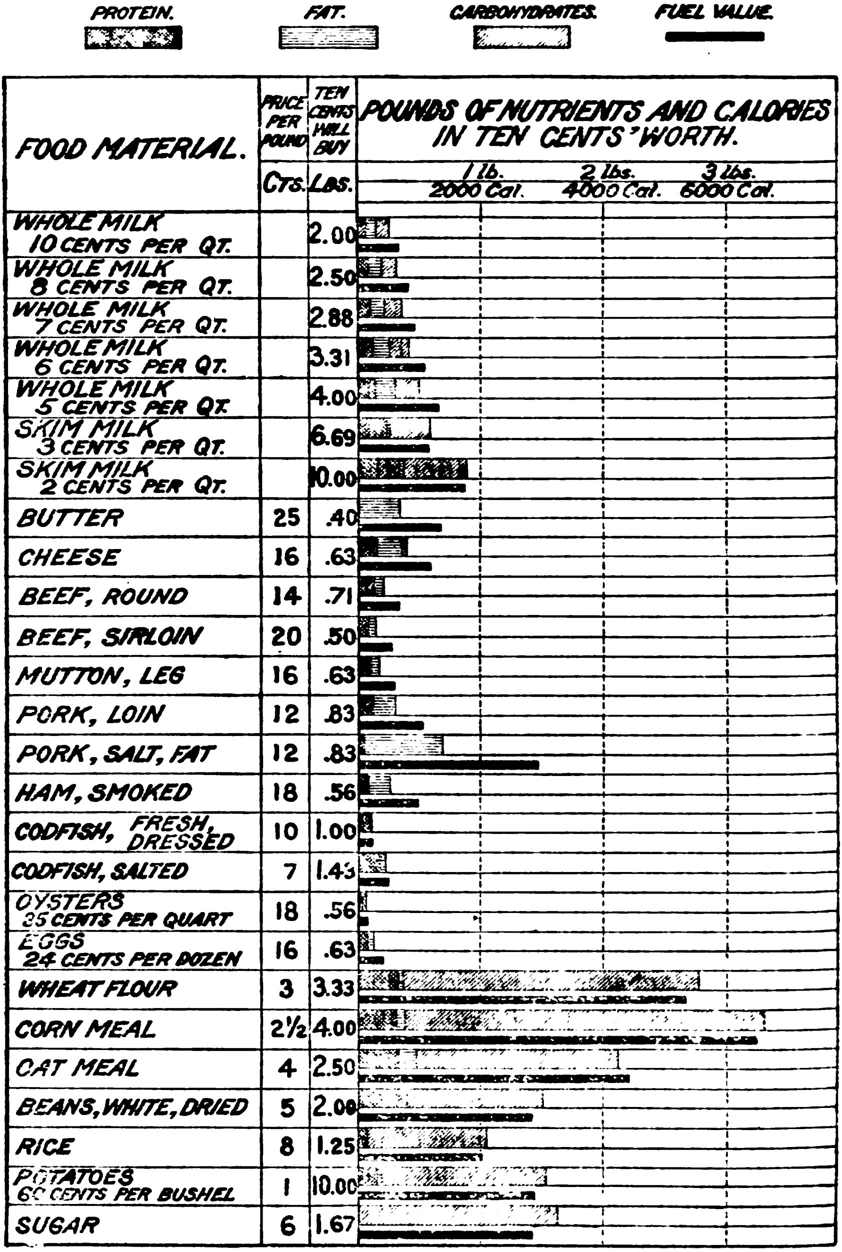
The accompanying chart will help in showing the real cheapness or dearness of milk at various prices as compared with other foods. In this chart the amount of nutrients is indicated by the shaded portions corresponding to the protein, fat, and carbohydrates, the length of each portion representing the number of pounds or fractions of a pound of the constituent which is supplied, each full division of the chart being equivalent to 1 pound. The heavy black line indicates the number of calories per pound, each full division of the chart corresponding to 2,000 calories.

The whole milk represented contains the average amounts of solid matter, regardless of price. Milk selling at 10 cents a quart ought to contain larger proportions than that selling at 5 or 6, besides having fewer bacteria; on the other hand, milk at the lower prices may occasionally contain larger proportions than the more expensive, but it is impossible to represent such variations satisfactorily. For the purposes of the present comparison the average composition will be sufficiently accurate.

Of course, in comparing milk and such material as dried beans, one must take into account the fact that the beans will absorb considerable water in cooking and that a pound of them ready to eat would not contain as much nourishment as is represented in the chart, while milk is consumed as bought. In addition, the cost of cooking must always be considered in connection with foods which are not eaten raw.

Bearing these things in mind, we see that milk at all but the highest prices assumed is a cheaper source of protein than any of the animal foods except cheese, very cheap meat, and salt fish. At usual prices skim milk furnishes protein more cheaply than any common animal food except salt fish. The protein of vegetable foods is less expensive, but, on the other hand, as prepared for the table is less thoroughly digested. Moreover, it is accompanied by such large amounts of

CHART III.—*Pecuniary economy of milk and other foods. Amount of actual nutrients obtained in different foods for 10 cents at certain assumed prices per pound.*



FOOD MATERIAL.	PRICE PER POUND. Cts.	TEN CENTS WILL BUY Lbs.
WHOLE MILK 10 CENTS PER QT.		2.00
WHOLE MILK 8 CENTS PER QT.		2.50
WHOLE MILK 7 CENTS PER QT.		2.88
WHOLE MILK 6 CENTS PER QT.		3.31
WHOLE MILK 5 CENTS PER QT.		4.00
SKIM MILK 3 CENTS PER QT.		6.69
SKIM MILK 2 CENTS PER QT.		10.00
BUTTER	25	.40
CHEESE	16	.63
BEEF, ROUND	14	.71
BEEF, SIRLOIN	20	.50
MUTTON, LEG	16	.63
PORK, LOIN	12	.83
PORK, SALT, FAT	12	.83
HAM, SMOKED	18	.56
CODFISH, FRESH, DRESSED	10	1.00
CODFISH, SALTED	7	1.43
OYSTERS 35 CENTS PER QUART	18	.56
EGGS 24 CENTS PER DOZEN	16	.63
WHEAT FLOUR	3	3.33
CORN MEAL	2½	4.00
OAT MEAL	4	2.50
BEANS, WHITE, DRIED	5	2.00
RICE	8	1.25
POTATOES 60 CENTS PER BUSHEL	1	10.00
SUGAR	6	1.67

.63

carbohydrates that to secure much vegetable protein in the diet usually means an excess of the carbohydrates. Under ordinary market conditions milk, and even skim milk, is a cheaper source of body fuel than any of the usual animal foods except cheese and salt pork, but is a dearer one than the usual vegetable foods. Here again, however, the milk furnishes the ingredients in a form more readily and thoroughly digested than the vegetable foods as ordinarily served. Milk, then, is fully as economical a source of nutrients as most animal foods, but is dearer than most vegetable foods. It has the decided advantage of having no waste, requiring no time for preparation, and being more digestible than the vegetable foods. Skim milk answers the most important purposes of milk in the ordinary mixed diet, and under usual market conditions costs at most only half as much as whole milk. Both whole and skim milk at moderate prices are therefore to be ranked among the most economical of our foods, not only when taken as beverages, but also when used in preparing other foods.

THE USE OF MILK IN COOKING.

If freely used in the preparation of other foods, milk can be made to add considerably to the food value of the meals. Many dishes are, of course, richer in flavor if whole milk is used rather than skimmed, but for the purpose of increasing the food value of the diet the main nutritive ingredient—that is, the nitrogenous material—as we have seen, is in the skim milk; if the extra fat is needed, it may be supplied in the form of butter, which is usually a more economical source than whole milk, or in the form of lard or other culinary fat.

Most persons consider that the choice between bread made with milk and that made with water depends simply upon the taste and appearance. There is, however, a difference in the food value, as will be seen from figures showing the average composition of various foods prepared with milk and of similar dishes in which it is not used. According to the figures which were taken from analyses made at the University of Minnesota,[a] bread made with skim milk is richer in total solids, protein, and fats than otherwise similar bread made with water. The differences are not very great, but they are well worth considering, especially where skim milk is a drug in the market. The importance of skim milk in bread making has also been demonstrated experimentally at the Maine Experiment Station.

Milk soups furnish an excellent means of increasing the food value of a meal or of using up superfluous milk. Sometimes the milk is mixed with " stock " made from meat, and sometimes, as in vegetable purées, it forms the basis to which the pulp of some vegetable, such as beans, peas, potatoes, corn, or celery, is added to give flavor and

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[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 67.

"body." Oyster stew made with milk owes its food value more to the milk than to the oysters.

Milk or "white" and "cream" sauces are also very useful, not only for the nutritive material they supply but also as a help in using up "left overs." Bits of meat can often be made very attractive by serving them on toast minced and "creamed," and many warmed-over vegetables are improved by the addition of milk or white sauce, while the same sauce also helps in giving variety in winter when not many kinds of vegetables are to be had. There is almost no end to the puddings and desserts in which considerable milk is used. Blanc mange is practically flavored milk, jellied with starch, Irish moss, or some similar material, and the simplest kinds of ice cream are milk and cream mixtures flavored and frozen. Junket is simply milk curd separated by rennet, as in cheese making, and eaten before the bacteria which give the cheese its flavor develop. Then there are all the puddings made of some form of cereal and milk and flavored in some way, as bread puddings, cornstarch, rice, and tapioca puddings, and the countless forms of custard of which milk and eggs make the basis. Almost all of these, if carefully made, are nutritious, easily digested, and economical. For children and persons of weak digestion the simpler ones like blanc mange, cornstarch, and rice puddings are almost indispensable.

MILK PRODUCTS.

BUTTER AND CHEESE.

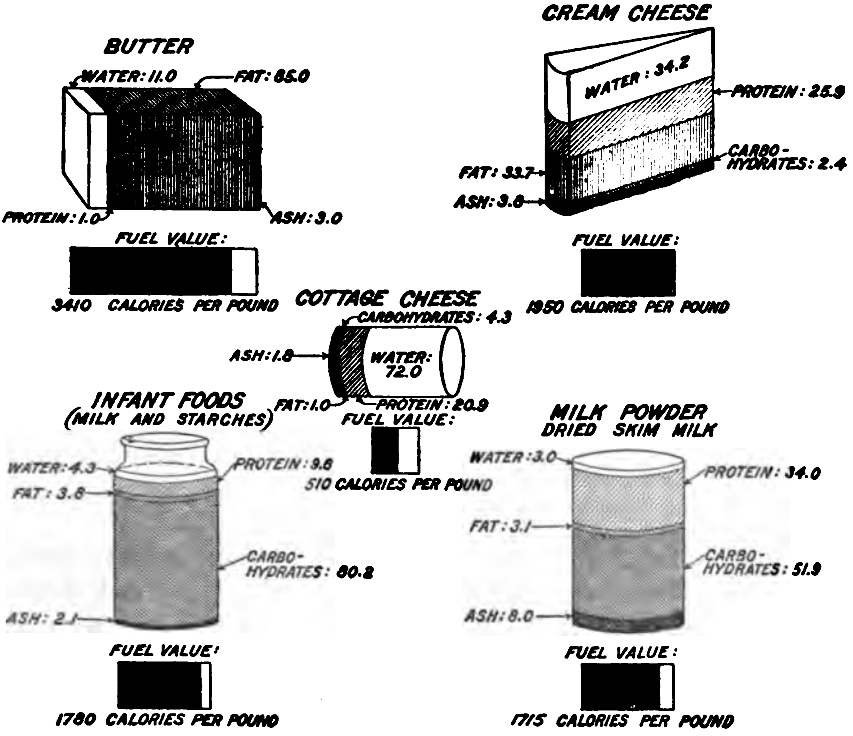
These are by far the most important products of the dairy industry, but so much has been written of them in other publications of this Department that they need only be mentioned briefly here.

Chart IV shows in graphic form the composition of butter, cheese, and other milk products. The data are given in tabular form for these and other foods on page 9.

Butter, which is practically separated milk fat, is one of the most important sources of fat in our diet and certainly the most palatable and one of the most digestible. Its flavor depends upon such factors as volatile fats, cleanliness, the action of bacteria, and the amount of salt added. The price varies greatly, even during the same season, and is influenced by flavor, color, texture, etc. These factors affect quality rather than composition, and so far as is known have little effect on nutritive value or digestibility. As has been stated already, it is usually a cheaper source of pure fat than whole milk. The butter on sale in the United States is usually salted, partly because of the general preference for the salt flavor and partly because of improved keeping qualities. It is noticeable that butter is now less heavily salted than was the case before cold storage and other such conveniences became common. In Europe sweet or unsalted butter is very popular, and its popularity is growing in the United States. Such butter has a mild, creamy flavor, which very many relish. As it does not keep well it must be used soon after it is made, and ranks as a delicacy. Many persons make sweet butter at home as needed, using for the purpose an egg beater or one of the devices similar in principle which are on the market for this purpose.

CHART IV.—*Percentage composition and fuel value per pound of butter, cheese, and other milk products.*

(The constituents are expressed in per cent, the fuel values in calories per pound.)



A peculiar form of butter, called "ghee," is commonly used in India and central Asia. The water is boiled out from freshly made butter and the resulting product is kept for general use, especially in cooking. In the cold, high regions of Tibet it is used in large quantities, lumps of it being put even into tea. This product is very similar to the rendered butter which is used by orthodox Jews in kosher cookery. Rendered butter is also a common culinary fat in Egypt and some other countries.

Cheese consists of the casein of the milk and more or less of the fat and mineral matters which are precipitated along with it when rennet is added to milk. There are countless varieties made not only from cow's milk but also from that of goats, ewes, and other animals. The flavor is due chiefly to the action of ferments, of bacteria, or of molds. The changes which these agents induce are now well understood, and the manufacture of cheese of different types is an important industry in which the expert cheese maker now utilizes them according to scientific methods to bring about the desired results with almost unvarying certainty. The literature of food and nutrition contains little definite information regarding the digestibility of cheese, but there is a general opinion that this food, particularly the very strong varieties, is less easily digested than most milk products. As regards thoroughness of digestion, a very large number of digestion experiments carried on by the Office of Experiment Stations in cooperation with the Bureau of Animal Industry of the Department of Agriculture have shown that, when consumed even in relatively large amounts, cheese is very thoroughly assimilated. Furthermore, it caused no physiological disturbances in the large number of tests in which it was used. Cheese, containing, as it does, almost all of the protein and fat of the milk from which it is made and having a comparatively low water content, is a very nutritious food, and the cheaper kinds may well be used more abundantly than is commonly the case in this country as a part of the regular diet and not simply as a condiment at the end of the hearty meal. The cost of cheese varies greatly with the kind, but the higher prices are usually paid for distinctive flavors or texture rather than for food values.

JUNKET.

A favorite dish for invalid dietetics and for more general use is prepared by adding rennet to milk and allowing it to stand undisturbed until it thickens or coagulates—that is, until the casein is precipitated. If the process is carefully carried out a thick, custard-like product results. If, however, it is stirred the casein readily breaks up and separates from the whey. There are a number of preparations of rennet on the market designed especially for making junket, all of which seem to give satisfactory results.

COTTAGE CHEESE.

Cottage cheese as commonly made at home from sour milk with or without the cream is a nutritious and palatable food, as may be seen from figures for its composition in the table on page 9, and the data given in Chart IV, page 37. Under ordinary conditions it is very inexpensive. There are several sorts of this cheese on the market which are made in large quantities as regular commercial products and sold under such names as Neufchatel, or, less commonly, cream cheese. In many city markets the homemade product may also be purchased. Cottage cheese is used as a palatable addition to the diet, alone or seasoned in various ways, and is also used in the preparation of a number of dishes.

CREAM.

Cream is made up principally of water and the fat of milk, but contains also a little protein, carbohydrates, and mineral matters. When served with cereals, fruit, etc., it not only improves the flavor, but adds to the nutritive value of the dish. When added to the custards, cakes, soups, and other food it materially increases the fat content and makes the dish "richer," as does cream, either plain or whipped, served with a dessert dish or other food.

Judging by available data, cream in large quantities is less easily digested than the same amount of whole milk, because it contains so much fat; but, on the other hand, it is more thoroughly digested than most other forms of fat, and is often ordered by physicians when the amount of this ingredient in the diet is to be increased. At usual prices it is so expensive that it must be considered a luxury to most people who purchase their milk and cream.

When cream is beaten or whipped the fine bubbles formed do not break readily, so that it may be whipped until it is stiff, almost like egg white. If the "whipping" is too long continued the fat globules separate, and butter results. If cream is too thin it does not whip well, and the same may be said of very thick cream. Several explanations of this property of "whipping" have been offered, but it seems fair to say that no entirely satisfactory explanation has been given. That the property may be dependent upon the calcium content of the milk is suggested by the fact that cream to which a small amount of a solution of lime in sugar and water has been added may be readily whipped. This question has been carefully studied at the Wisconsin Station, and it was found that if a small portion of such a lime solution was added to pasteurized cream which ordinarily does not whip readily, or to thin cream, satisfactory results could be obtained.

A cream product known as "Devonshire clotted cream," or simply as "clotted cream," and very popular in Great Britain and, to a less extent, elsewhere, is made by allowing pans of milk to stand undisturbed in a cool place until cream rises and then scalding, care being taken not to disturb the cream on top of the milk. When this is properly done and the pans allowed to cool, the cream may be taken off in a thick, clotted condition, and is ready for use. It has a peculiar, nutty flavor, which most persons relish.

BUTTERMILK.

Besides skim milk, there is another important by-product resulting from the manufacture of butter, namely, buttermilk. In butter making the fat globules are brought together by churning and removed, leaving a thin liquid. This buttermilk is very like skim milk in composition, but it has usually a mild acid taste, because the cream is generally allowed to sour before churning. Buttermilk is often used as a beverage, and has much the same food value as skim milk. An ordinary glass would contain about as much nourishment as 2 ounces of bread, a good-sized potato, or a half pint of oysters. To many persons buttermilk is as palatable, or even more palatable, than whole or skim milk, but others find the sour taste very unpleasant. This sour taste is due mainly to lactic acid, and does not make the buttermilk less digestible. On the contrary, its casein forms a more flaky curd than that of ordinary milk. Buttermilk is frequently fed to babies, especially in Holland, and is sometimes prescribed when the protein of ordinary milk proves indigestible. Its general use is increasing in this country. Buttermilk ice cream is considered a delicacy in some sections, especially for invalids.

Condensed buttermilk is manufactured to some extent, but seems to be best known in Europe, and is certainly not common even there.

WHEY.

Just as buttermilk represents the residue of milk from butter making, so whey represents what is left from cheese making, and consists mainly of water, milk sugar, and mineral matters. It is less nutritious than skim milk and buttermilk, but is occasionally useful as a mild laxative drink for invalids. In the "whey cures" for dyspeptics, of which so much was heard some years ago, whey was usually combined with a simple vegetable diet and the beneficial results were probably due as much to the simple, out-of-door life, which made part of the treatment, as to the whey itself.

Whey may be made at home by cooking sweet milk with some acid material, such as vinegar, lemon juice, sour wine, or cream of tartar, or even with sour milk. Such whey differs but little in composition from regular cheese whey. Fresh curds and whey is an old-fashioned dish still used to some extent, though less common than it was when cheese making was regularly carried on as a home industry.

SOUR MILK OR CLABBER.

Sour milk or clabber is a common article of diet in many parts of the United States and is wholesome, and to those who care for it very refreshing and palatable. It is certainly nutritious, since when made from whole milk it contains all the nutritive ingredients originally present, and when only skim milk is used it contains the casein and other constituents except the fat. Usually no special methods are followed to prepare sour milk or clabber for table use, though most housewives recognize the fact that if the souring takes place too slowly the clabber may have a bitter or unpleasant flavor. This is, of course, due to the development of undesirable bacteria along with those which cause the souring of the milk. Sour milk is much used in cookery, and adds materially to the nutritive value of the dish of which it forms a part. Before baking powders became so common sour milk and baking soda were very commonly used to leaven doughs and batters of various sorts. Some cooks maintain that they can secure the best results by using only the whey of sour milk, but this naturally gives a less nutritious dish and therefore is not so desirable.

KEPHIR, KOUMISS, AND OTHER FERMENTED MILK PRODUCTS.

Since earliest times fermented-milk products have been used as beverages and articles of diet in Central Asia, Turkey, and other countries. These products are prepared by allowing special ferments or yeasts to develop in milk, and like all fermented beverages owe their sparkling or effervescent qualities to the carbon dioxid produced by the action of organisms. The flavor differs with the process of manufacture. These fermented-milk beverages have proved very satisfactory in invalid dietetics and are now well known and commonly used. Fermented-milk beverages may be made at home, but are perhaps more commonly commercial products in the United States. In this country cow's milk is almost universally used to make these beverages, but other milk, for instance, mare's milk, is more common in Central Asia and other regions.

A carbonated milk, which is made by charging milk with carbon dioxid, is sometimes found on sale, but, of course, lacks the special qualities which all the fermented products contain.

Some of these fermented-milk products contain lactic acid forming bacteria in great abundance, and their extensive use has been much discussed recently, owing to the prominence which has been given to the theory that very many diseases, particularly those incident to old age, are the results of the development of putrefactive bacteria in the intestine and the possibilities of hindering the growth of such organisms by the presence of lactic acid. The most recent observations, however, make it doubtful whether it is as beneficial as has been claimed by some enthusiasts.

SUMMARY.

Some idea of the importance of milk as human food may be gained from the fact that about one-sixth of the total food of the average family is furnished by it and its products. Milk from various mammals is used in various parts of the world, but with us that of the cow so far surpasses all other kinds in importance that unless otherwise specified the word "milk" is taken to refer to cow's milk only. Few staple foods vary so much in composition, but, on the average, good, unadulterated milk should contain about 87 per cent water and 13 per cent solids. About one-fourth of these solids are furnished by the protein compounds, casein, and albumin, the casein being five or six times more abundant than the albumin. Fats (butter fat) form one-third of the total solids. Butter fat occurs in globules throughout the milk, and it is upon the size and number of them that the creaminess of milk depends. The larger the globules the more easily and completely will they rise as cream to the surface of the milk. Carbohydrates make up 38 per cent of the solids, by far the most important of them being lactose, or milk sugar. The remaining 5 per cent of solids consists of mineral matters, the bulk of which are phosphates and chlorids of soda, potash, and lime.

Besides these chemical constituents, milk almost inevitably contains bacteria of many kinds and in varying numbers. They cause the souring of milk and the ripening of cream and cheese, and produce many other changes in the appearance and flavor. The number present in freshly-drawn milk varies enormously with the conditions of milking, and, as they are greatly increased with dirty and careless handling, cleanliness in all matters pertaining to the milking and marketing of milk and keeping it in the home can not be too strongly insisted on. Disease germs, notably those of typhoid, diphtheria, scarlet fever, and tuberculosis, may also be carried in milk, so that the purity of the milk supply is of vital importance to every family and community.

Although some of the bacteria in milk are essential in the manufacture of butter and cheese, they are as a class a source of danger to the ordinary consumer. Without them milk would stay sweet indefinitely, and the problem of keeping milk is simply one of checking their growth. The less there are in the fresh milk, the slighter the danger, hence the superior keeping qualities of milk from a clean, well-ordered dairy. They are comparatively inactive at a temperature below 50° F., and therefore milk should be kept in a cool place. Freezing does not kill bacteria and produces undesirable changes in the milk. Extreme heat does kill them, but also produces other undesirable changes. Nevertheless, heat is employed to preserve milk in the two common methods of pasteurization and sterilization. In the former the aim is to apply heat in such a way as to kill the most bacteria without producing the undesirable changes; in the latter, to apply enough heat to kill all the bacteria, but with the least possible undesirable change. Bacteria require moisture as well as heat for their growth, therefore by extracting the water, as in condensed milk, milk powders, etc., milk may be preserved indefinitely. Another way of keeping it is by the use of chemicals to kill the bacteria, but as such chemicals may be injurious to human beings as well, such practices are not usually to be recommended.

What is commonly known as the richness of milk depends upon the amount of fat. This varies so greatly in milk from different animals and is so easily reduced by a fraudulent dealer that many efforts have been made to regulate the price of milk according to its fat content. Milk graded according to government standards is sold in some cities, especially in Europe. Certified milk—that is, milk in sealed jars from establishments regularly inspected—is more commonly known in this country, and rightly commands a higher price than that from uncertain sources. Of course, cleanliness and care are as important in keeping milk in the home as in the dairy and market, and each housekeeper should see to it that all receptacles in which it is kept are thoroughly scalded each time they are used; if this is neglected, bacteria from the old milk will contaminate the fresh.

Compared with other food materials, milk furnishes the nutritive ingredients in forms in which they may be easily and thoroughly digested by the normal, healthy person, and often by those of impaired health. Boiling is believed by many to make the protein slightly less digestible, but as yet knowledge on this point is incomplete. The digestibility of the fat seems to depend upon the size of the globules, the smaller ones being more easily absorbed. This explains why rich, "creamy" milk, such as that given by the Channel breeds, sometimes causes digestive trouble in children.

Mother's milk is best adapted by nature to the nourishment of infants, and differs from cow's milk mainly in the character of its protein, in the smaller size of its fat globules, and in its greater amount of milk sugar. When necessary, cow's milk may be artificially modified to approach it more nearly in composition, but the results are not always satisfactory, especially as regards the protein.

Milk contains too much water to be a perfect food for adults; nevertheless, its solids furnish all the necessary ingredients and in good proportions. A large glass of it yields as much nourishment as a slice of roast beef.

Unless exceptionally high prices are paid for it, milk is fully as economical a source of nutrients as other animal foods, but dearer than most staple vegetable products. It should be borne in mind, however, that it requires no preparation, has no waste, and is more thoroughly digested than most vegetable foods. As a source of protein, the most expensive of the nutritive ingredients, it is especially economical. Skim milk, which is whole milk minus part of its fat, and which costs only half as much as whole milk, furnishes protein about four times as cheaply as beef, and since fat is usually abundant in the ordinary mixed diet might most advantageously be used in the place of whole milk in dietaries where cost must be carefully considered. The freer use of skim milk in cooking is also to be recommended. Of course, foods prepared with either skim or whole milk are by so much the more nutritious than those prepared with water.

Butter and cheese are the most important milk products. Butter is one of the chief sources of fat in the ordinary diet and furnishes it in a very palatable and easily digested form. Cheese consists of the casein of milk plus more or less of the fat and mineral matters. The flavor and texture of the many varieties are due mainly to the peculiar bacteria and ferments which the various methods of manufacture develop. The less expensive varieties make one of the cheapest sources of protein, and might well be more freely used as part of the regular diet. Digestion experiments indicate that the common and milder varieties are more easily and thoroughly assimilated than is sometimes supposed. The other milk products—junket, whey, buttermilk, clabber, and the fermented forms, such as kephir and koumiss—are all nutritious foods and are often of especial value in invalid diet. In short, milk and its products are fully entitled to their prominent place in our food list as comparatively inexpensive, easily digested sources of all the necessary ingredients of our diet.

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Issued August 21, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 364.

A PROFITABLE COTTON FARM.

BY

C. L. GOODRICH,
Expert, Office of Farm Management,
Bureau of Plant Industry.

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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 24, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "A Profitable Cotton Farm," prepared by Prof. C. L. Goodrich, Expert, under the direction of the Agriculturist in Charge of the Office of Farm Management of this Bureau. The paper contains a description of a South Carolina cotton farm and the methods of management by which it was changed from a failure to a profitable enterprise.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 7
Description of the cotton farm 7
Management of the farm 8
Plowing 9
Surface drainage 10
Methods of growing the crops 10
  Cotton 10
    Preparation of the soil 10
    Manure and fertilizers 13
    Varieties planted 13
    Cultivation 13
  Corn 14
    Preparation of the soil 14
    Planting 14
    Fertilizers 14
    Cultivation 14
    Harvesting 15
  Oats 16
  Cowpeas 17
Live stock 17
Equipment of the farm 18
Cost and value of crops produced in 1908 18
Use of fertilizers 19
Recommendations regarding winter cover crops 21
Summary 21
Some features of the system of management described applicable to many farms. 23

ILLUSTRATIONS.

Page.
FIG. 1. Plan of the farm when purchased in 1902 7
2. Plan of the farm in 1908 8
3. Buildings on the farm 9
4. Cattle shed and barns 10
5. A straight-shovel plow and a "middle buster," or opening plow 11
6. Field showing "black" manure in cotton furrows 11
7. Field showing manure covered in cotton furrows 12
8. A fertilizer distributer and a side harrow 12
9. Field with corn planted in deep furrows 15
10. Field of oats planted by plowing under shallow 16
11. Diagram showing the relation of the quantity of commercial fertilizer used to yields of cotton on field A 20
12. Diagram showing the relation of the quantity of commercial fertilizer used to yields of corn on field B 20

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A PROFITABLE COTTON FARM.

INTRODUCTION.

This bulletin is an account of the progressive and successful farm operations of a farmer of South Carolina who, by combining thorough tillage, crop rotation, barnyard manure, and a judicious use of commercial fertilizer, has changed a previously badly managed and run-down cotton farm into a very productive and profitable enterprise. The impulse prompting the writing of this bulletin is the belief that it may suggest to other farmers of the South ways and means by which they may so improve their methods of management as to make their farms more profitable.

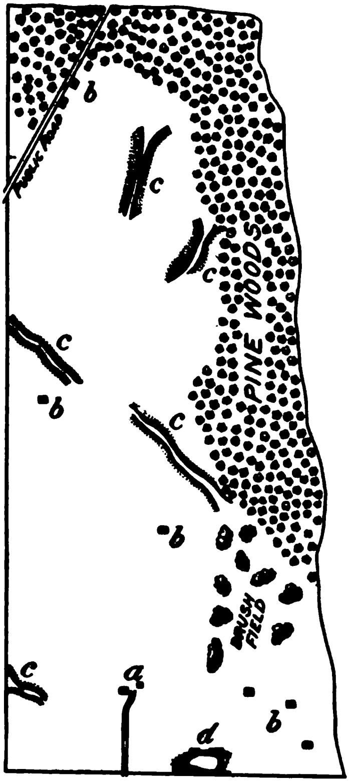

FIG. 1.—Plan of the farm when purchased in 1902: *a*, Old farm buildings; *b*, tenant houses; *c*, gullies; *d*, pond and swamp.

DESCRIPTION OF THE COTTON FARM.

The farm described is located in the east-central part of South Carolina. It lies on a low, sandy ridge having good drainage, the land sloping in all directions from the central ridge like a turtle's back. The soil is a gray sandy loam, in some parts quite loose and almost white in color. It is underlain at a depth of 12 to 15 inches by a yellow sandy subsoil. The forest growth is pine and scrub oak. There are 131¾ acres in the farm, of which 66 acres are under a system of rotation and 30 are occupied by tenant houses and their surrounding lots. The remainder is woodland. The farm has been under cultivation some eighty years, and for the eight or ten years previous to the present ownership had been rented.

Figure 1 gives some idea of the condition of the farm when the present owner took possession in January, 1902. Several tenant houses were scattered promiscuously over it, a number of bad gullies had been allowed to develop, a swamp hole occupied part of one field, and clumps of scrubby trees, bushes, and broom sedge had grown up, making the fields irregular in shape and giving the farm a rough and unthrifty appearance. The fertility of the soil had been reduced to the low ebb of producing 300 pounds of seed cotton and 5 to 8 bushels of corn to the acre.

Now this is all changed; the borders of the fields have been straightened, the tenant houses moved from the tillable lands, gullies filled up, and the swamp hole drained. The tillable land has been divided into three fields, of 22 acres each; the farm has been fenced; and a new house, barn, and other buildings have been erected. The farm to-day presents an appearance of neatness, thrift, and prosperity.

Figure 2 is a plan of the farm as it is to-day. Figures 3 and 4 give some idea of the buildings.

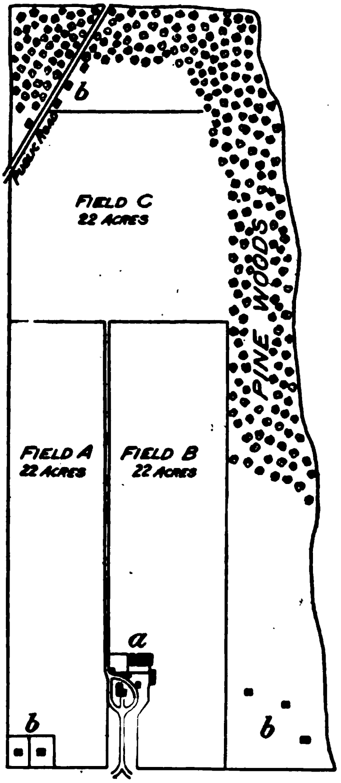

Fig. 2.—Plan of the farm in 1908: *a*, New farm buildings; *b*, tenant houses.

MANAGEMENT OF THE FARM.

The present owner was a farmer of experience when he purchased the farm, and he knew the value of the rotation of crops, thorough tillage, and the importance of decaying organic matter, or humus, in the soil. He adopted a rotation, bought stable manure, and began feeding cattle for the purpose of converting part of the roughage and grain of the farm into animal products and making farm manure for use on the land. By this method and by the judicious use of commercial fertilizer he succeeded in producing the first year a yield of 1⅜ bales of cotton, 37 bushels of corn, and 10 bushels of oats to the acre. These yields have been gradually increased, until during the last two years 2¼ bales of cotton, 85 bushels of corn, and 80 bushels of oats per acre have been obtained.

The rotation adopted was as follows: First year, corn, with cowpeas planted between the rows at the last working of the corn: second year, winter oats, followed by cowpeas for hay, and third year, cotton. The system of cropping and the yields for each field are given in Table I.

TABLE I.—*Cropping system and crop yields, 1902 to 1908, inclusive.*

Year.	Field A.		Field B.		Field C.	
	Crop.	Yield.	Crop.	Yield.	Crop.	Yield.
1902	Cotton....	1.6 bales..........	Corn [a]	37 bushels	Oats [b].....	10 bushels.
1903	Corn [a]	50 bushels	Cotton....	1.8 bales	Oats [b].....	45 bushels.
1904	Oats [b].....	60 bushels	Corn [a]	65 bushels	Cotton....	1.68 bales.
1905	Cotton....	2.14 bales.........	Oats [b].....	75 bushels	Corn [a]	62 bushels.
1906	Corn [a]	75 bushels	Cotton....	2 bales............	Oats [b].....	60 bushels.
1907	Oats [b].....	75 bushels	Corn [a]	85 bushels	Cotton....	1.7 bales.
1908	Cotton....	2.27 bales.........	Oats [b].....	80 bushels	Corn.....	62 bushels.

[a] With cowpeas.

[b] Followed by cowpeas.

The three fields varied somewhat in fertility, A being the best, and C being of a very poor, loose white sand. The very poor condition of field C, indicated by the low yield of the first crop of oats, accounts for the slight irregularity in the cropping systems of fields B and C at the beginning, as it was not considered advisable to plant cotton on field C until a second crop of peas had grown on it. A study of the table shows an immediate return for good management and a gradual increase in crop production. This increase in crop production has been accompanied by a reduction in the amount and the cost of commercial fertilizers used. (See p. 20.)

FIG. 3.—Buildings on the farm.

PLOWING.

Previous to the present occupancy of the farm the soil had been plowed 3 to 4 inches in depth in preparation for crop planting.

Under the present management the soil has been plowed broadcast for both cotton and corn with a 2-horse turning plow cutting 10 inches deep, followed by a 1-horse subsoiler breaking the furrow bottom to an additional depth of 7 inches. This has given the land two deep and thorough plowings each round of the three-year rotation.

SURFACE DRAINAGE.

Under previous management the land on this farm washed and gullied somewhat. This has been largely overcome by deep and thorough tillage. However, to check the possibility of washing during exceptionally heavy rains the soil is now plowed in long beds 60 feet wide. This leaves it in a series of broad, low "lands" with shallow depressions between. During heavy rains such water as the soil can not immediately take up finds its way gradually to the shallow depressions, which, having no outlets, hold it until it slowly sinks into the subsoil. As this soil is open and porous in texture and absorbs water readily, there is no danger of puddling from water standing in the furrows between the lands, and this method of plowing eliminates the necessity of terracing.

FIG. 4.—Cattle shed and barns.

METHODS OF GROWING THE CROPS.

The present management of the individual crops is as follows.

COTTON.

Preparation of the soil.—In November the land is flat-broken or plowed broadcast 10 inches deep, in 60-foot beds, with a 2-horse turning plow. A 1-horse subsoil plow follows the turning plow, breaking the furrow bottom to a depth of 7 inches. The field is then harrowed with a 3-section smoothing harrow. In January the field is laid off with a 1-horse plow, marking furrows being run 5 feet apart. Two furrows are then thrown together on to the marking furrow and the middles are broken deep with a 2-horse middle breaker or double moldboard plow (see fig. 5), leaving a deep, wide furrow.

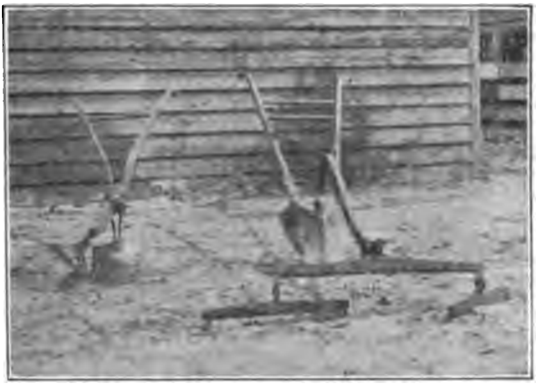

FIG. 5.—A straight-shovel plow (on the left) and a "middle buster," or opening plow (on the right).

"Black"[a] manure is then hauled to the field, dumped into piles, distributed in the furrows (see fig. 6), and covered as rapidly as possible (see fig. 7) in order to prevent its drying. The covering is done by running down each side of the furrow with a bull-tongue, or subsoiler, which covers the manure and again stirs the lower soil. The field is then left until planting time.

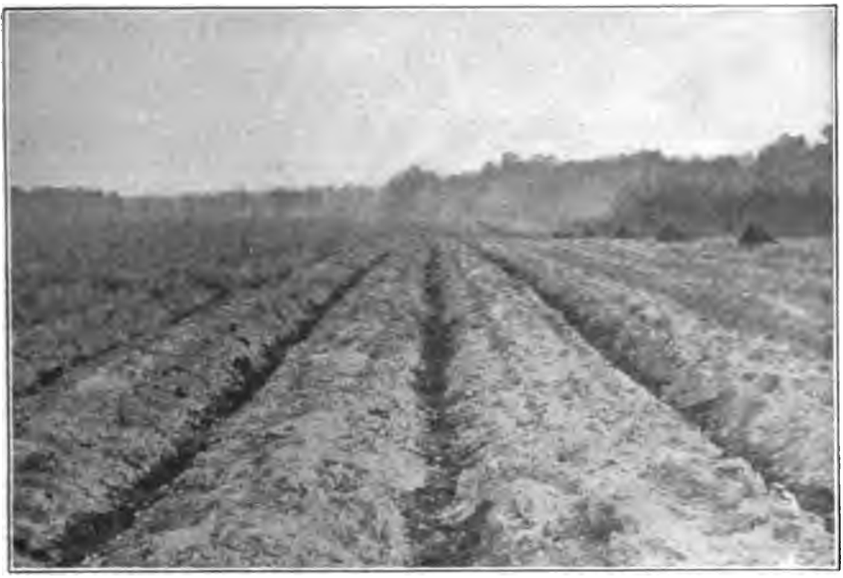

FIG. 6.—Field showing "black" manure in cotton furrows.

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[a] A southern term for barnyard manure.

Just before planting, a bull-tongue plow is run down the row to mix the manure with the soil thoroughly and to open the furrow for the reception of commercial fertilizer, which is applied with a distributer. (See fig. 8.) Two furrows are then turned onto this manure and fertilizer, making a low bed on which the cotton planter is run. This early application and immediate covering of the

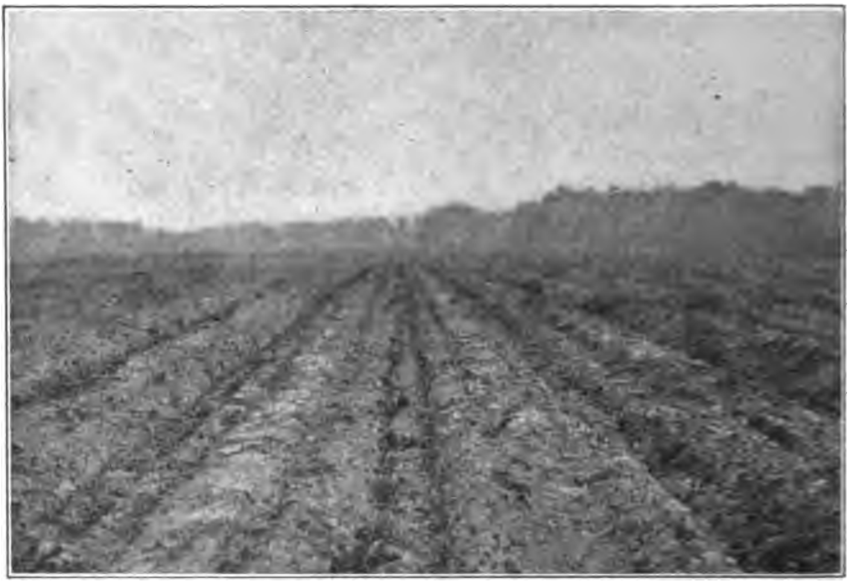

FIG. 7.—Field showing manure covered in cotton furrows.

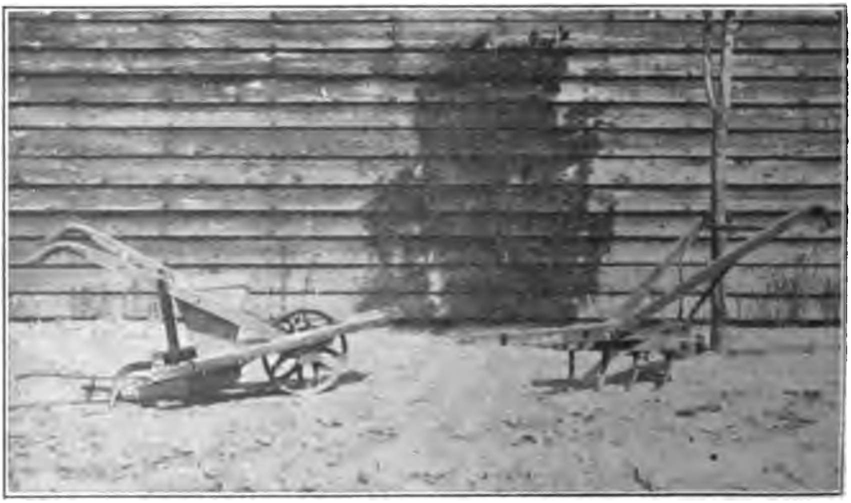

FIG. 8.—A fertilizer distributer and a side harrow.

"black" manure in a well-rotted and moist condition, its further rotting during the eight or ten weeks before planting, and the thorough mixing of it with the soil eliminate all danger of causing the crop to "burn" in dry weather, a condition which is apt to occur when barnyard manure is applied in a coarse, unrotted condition only a short time before planting.

Manure and fertilizers.—In 1902 five 2-mule loads of about 1 ton each of "black" manure were used to the acre in the furrows. This amount has been gradually increased until in 1908 seven loads per acre were used. This manure is partly purchased from a near-by livery and sales stable and partly produced by feeding to cattle roughage and grain grown on the farm.

In 1902, 1,200 pounds per acre of commercial fertilizer were used at planting time. This consisted of 500 pounds of 13 per cent acid phosphate, 500 pounds of cotton-seed meal, and 200 pounds of muriate of potash. About July 1 nitrate of soda was applied in the middles at the rate of 150 to 200 pounds per acre. In 1903 and 1904 the amount of fertilizer used at planting time was reduced to 900 pounds, consisting of 400 pounds of acid phosphate, 400 pounds of cotton-seed meal, and 100 pounds of muriate of potash. Since then only 300 pounds of acid phosphate, 300 pounds of cotton-seed meal, and 100 pounds of muriate of potash, a total of 700 pounds to the acre, have been used at planting time. The 150 to 200 pounds of nitrate of soda applied during the growing season have been continued each year. It has now been decided that the nitrate is not needed, and its use will be abandoned in the future.

Varieties planted.—The seed is planted about the first week in April. The "King" variety was used in 1902, then "Excelsior" until 1908, when "Money-Maker," somewhat mixed, was planted.

Cultivation.—About April 15, or as soon as the rows show up well, cultivation, or "working" the crop, begins, and continues as follows:

(1) A 4-toothed side harrow or cultivator (see fig. 8) is run on both sides of the row.

(2) As soon as the third leaf begins to show itself, chopping begins and the plants are thinned to a stand of one plant every 2 feet. At a later chopping every second plant is taken out and the stand reduced to an average of one plant every 4 feet in the row. This leaves the cotton plants 4 by 5 feet apart. In 1902, when the land was poor, the rows were run 4 feet apart and the plants thinned to 18 or 20 inches in the row, but as the land became more fertile and the plants grew larger it was necessary to give them more room.

(3) The third working consists in breaking the middles with a 2-horse plow or a 10-inch straight shovel.

(4) About a week or ten days later a 24-inch sweep is run down the rows, throwing just enough dirt to cover any small weeds that

may be appearing in the rows. Previous to making the rows 5 feet apart an 18-inch sweep was used for this working.

(5) A little later a 24-inch sweep is used, which levels the ground and destroys any weeds that may be appearing.

(6) Three more workings are given with the 24-inch sweep.

The deep furrow that is made for the reception of the stable manure at the time of preparation for the crop is not entirely filled up in bedding for the seed. This results in the cotton being planted in a shallow furrow. This method of planting lessens the amount of chopping or hand work necessary, for when the sweeps are run down the rows enough soil is allowed to fall into the depression or furrow to cover any weeds that may be starting, and when cultivation ceases the land is left practically level. This method of planting would not be advisable on close, stiff soil, as there would be danger of water settling in the furrow after heavy rains and injuring the plants. Neither could it be used on low lands where it is necessary to throw up ridges or beds in order to plant early.

CORN.

Preparation of the soil.—The cotton stalks are cut down with a stalk cutter and the land is plowed for corn in December. The plowing is the same as for cotton, namely, broadcast in 60-foot beds 10 inches deep with a turn plow, and subsoiled 7 inches deeper.

Planting.—About March 1 the land is laid off by running furrows 6 feet apart with a 2-horse opening plow, or middle breaker, as deep as 2 mules can pull it. The seed is then planted in the furrow. (See fig. 9.) In 1902 the corn was dropped 3 feet apart in the row; but as the soil has gradually improved the distance has been lessened to 15 or 18 inches.

Fertilizers.—In 1902–3, 200 pounds of a guano analyzing 8 per cent of phosphoric acid, 4 per cent of ammonia, and 4 per cent of potash were distributed in the furrows at planting time. This practice was discontinued in 1904. About June 15, or when the ears begin to shoot, a mixture of 200 pounds of 13 per cent acid phosphate, 200 pounds of cotton-seed meal, and 100 pounds of muriate of potash is scattered by hand beside the corn and worked into the soil.

Cultivation.—The care of the growing crop is as follows:

(1) About April 1 a furrow is broken out down the middles or between the rows of corn with a 10-inch straight shovel.

(2) May 1 to 10 a 1-horse plow with wings removed and fender attached is run down the planting furrow about 2 inches from the corn, the fender keeping the soil from the corn and the point simply stirring the soil without making a furrow.

(3) About May 15 a 1-horse plow with a small wing is run around the corn. This stirs the soil and makes a little bank next the corn, but throws no soil to it.

(4) About June 1 a 1-horse plow with a longer wing is run around the corn in such a way as to throw some soil into the middle furrow to cover any grass that may have started. This also raises the bank a little next to the corn, but throws no soil to the corn.

(5) About June 15, or at ear-shooting time, if a crust has formed in the center furrow it is broken. Peas are sown in the furrow and fertilizer is dropped next to the corn by hand, then one round with a 30-inch sweep covers the peas and fertilizer and levels the land. This completes the cultivation.

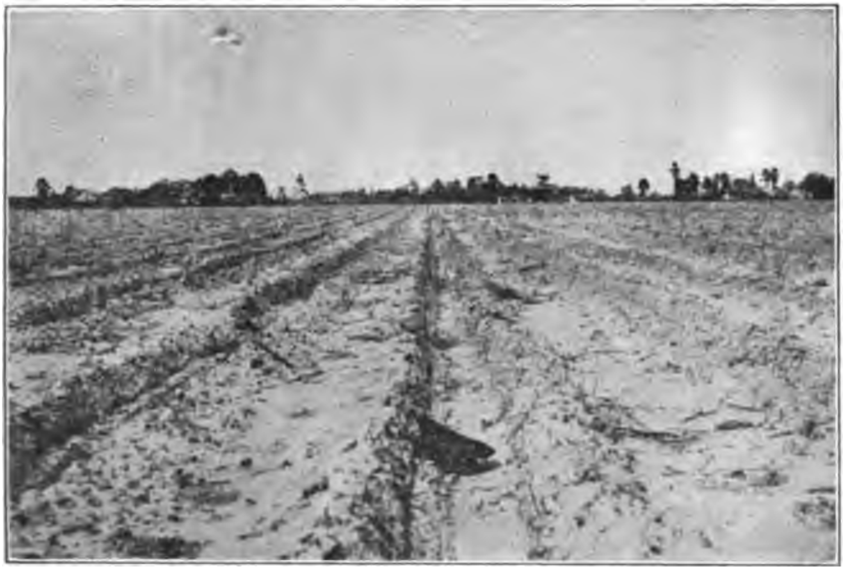

FIG. 9.—Field with corn planted in deep furrows.

Since 1905 the third and fourth workings have been omitted and the crop has been made with only three workings, namely, splitting the middles, running around the corn once with a Dixie point and fender, and covering the peas and the fertilizer and leveling the soil with a 30-inch sweep.

Harvesting.—The fodder is pulled by hand. In September the ears are broken off and hauled in and the stalks, the pea vines, and such crab-grass as may have grown are cut with a mower. The coarser stalks are separated in the curing of the hay and hauled to the cattle shed for bedding, the hay being used for feeding.

OATS.

The first crop of oats was planted in January, 1902, on field C. The land was plowed shallow and harrowed, then 2 bushels of oats were drilled in with 150 pounds of fertilizer (one-third each of acid phosphate, cotton-seed meal, and kainit). The yield obtained was 10 bushels per acre. This oat crop was followed by a crop of cowpeas, which were cut for hay.

Oats were again sown on the field in October, 1903, on the pea stubble. This crop was fertilized at planting time with 500 pounds of acid phosphate per acre and in the spring with a dressing of 100 pounds of nitrate of soda. The yield was 45 bushels per acre. Subsequent oat crops have been fertilized in the spring only, and then with 200 pounds of nitrate of soda, until 1908, when the soda was omitted.

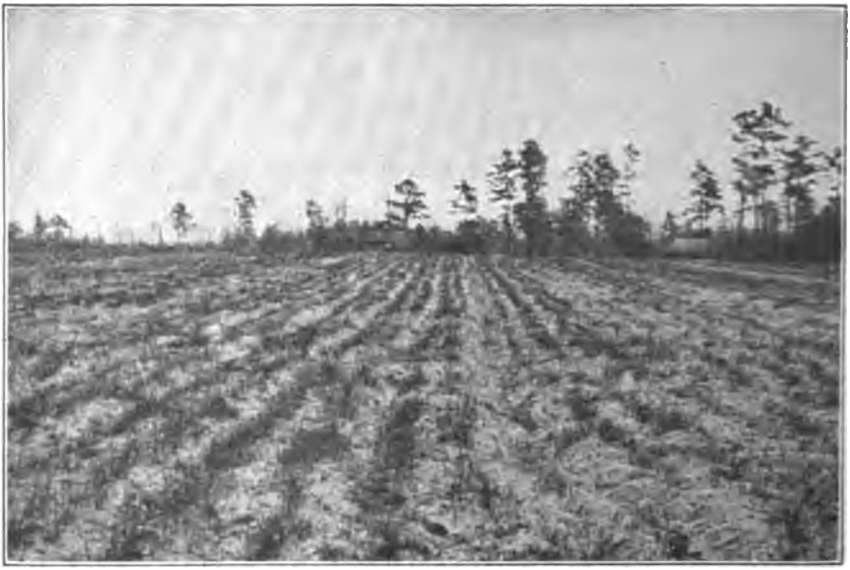

FIG. 10.—Field of oats planted by plowing under shallow.

Since 1902 oats have been sown broadcast on the corn and pea stubble in October and plowed under by turning a broad, shallow furrow. The field is then harrowed. When the oats are plowed under in this manner they roll to the lower side of the furrow slice, and when they come up the field has the appearance of having been drilled. (See fig. 10.) The oats are harvested with a binder.

COWPEAS.

In June, after the oat crop is harvested, cowpeas are sown broadcast on the oat stubble and plowed under by turning a wide, shallow furrow. No fertilizer is used. The yields have averaged about 2 tons of hay to the acre.

Cowpeas are planted between the rows of corn at the last working of the corn. Seed is saved from them. Previous to 1907, 150 to 200 bushels of seed have been harvested each year from the 22 acres planted. In 1907 only 100 bushels were gathered, and in 1908 the peas made no grain. There has been more or less pea wilt each year, which has reduced the yield of seed. The cowpeas usually make a good growth of vine, the wilt not attacking them until just before fruiting. The peas, which are sown after oats, are cut for hay before the vines are destroyed by the wilt, so that the crop is not a total loss. Next year the Iron cowpea will be used, on account of its wilt-resistant character.

In making cowpeas into hay the vines are cut with a mowing machine, then stakes are driven in the ground to stand about 4 feet high. The vines are then piled on these stakes. The stakes keep the vines up from the ground and allow a free circulation of air through the pile. The vines cure in about a week, and are then removed to the barn or sold directly from the field.

LIVE STOCK.

A feature of this farm found on comparatively few southern farms is the feeding of cattle primarily for the production of "black" manure, to be used under cotton. An average of twenty-five head of native stock is carried through the year, though the number varies at times from twelve to fifty, according to the rapidity with which the cattle are brought in and turned off. These cattle average 600 pounds in weight when purchased, and are fed on cottonseed hulls and meal, oat straw, cornshucks, and other roughage. The cattle have been kept in open yards until the present year, when a shed was built for their protection and for the protection of the manure. (See fig. 4, p. 10.)

The cattle are given the run of the fields between harvest and the preparation for the next crop. Cornstalks, straw, and cotton motes (cotton-gin refuse) are spread over the ground in the yards and under the sheds as bedding and absorbents. The manure accumulates during the year, and is hauled out in January and applied to the cotton land. The manure from the cattle, together with that from the four work mules and the two stock sows and their progeny, amounts to from seventy-five to one hundred 2-mule loads a year. In addition to this, forty to sixty loads are purchased from a near-by livery and feed stable. This manure, together with the cowpea stubble, has been the leading factor in increasing the fertility of the soil and thereby increasing crop products and profits.

EQUIPMENT OF THE FARM.

This farm carries four work mules and employs four contract hands, a force larger than is necessary for the actual work of the farm. When the laborers are not needed on the farm they are kept busy at outside work, at which they earn sufficient to greatly reduce their cost to the farm.

A statement of the tool and machine equipment of the farm and its value on January 1, 1908, follows:

Two 2-horse plows	$20.00
One opening plow or "middle buster"	10.00
Three 1-horse plows	4.50
One 3-section smoothing harrow (slant-tooth)	14.00
Three iron-headed scraper stocks	3.00
Attachments for scraper stocks:	
Two 18-inch sweeps Two 24-inch sweeps Two 30-inch sweeps One 5-inch straight shovel One 10-inch straight shovel	5.20
Amount brought forward	$56.70
One stalk cutter	35.00
One fertiliser distributer	7.00
One cotton planter	8.00
Two 4-toothed side cultivators	5.00
Two 2-horse wagons	100.00
One mower	40.00
One hayrake	20.00
One binder	115.00
The usual small tools, hoes, rakes, forks, etc	10.00
Total	396.70

COST AND VALUE OF CROPS PRODUCED IN 1908.

Cost of production of crops in 1908.

LABOR.		
4 men, 12 months (cash, rations, house rent)		$600.00
Picking 50 bales of cotton		375.00
Ginning 50 bales of cotton, at $1.25		62.50
4 mules' feed (raised on farm)		400.00
FERTILIZER.		
5½ tons of acid phosphate, at $12.25	$67.38	
5½ tons of cotton-seed meal (raised on farm), at $24	132.00	
2.2 tons of muriate of potash, at $42.50	93.50	
1.93 tons of nitrate of soda, at $53.50	103.25	
		$396.13
MANURE.		
154 loads for cotton (55 bought, 99 produced on farm), at $1.50		231.00
		627.13

Amount brought forward		$2,064 63

SEEDS.

22 bushels of cotton, at 25 cents	$5.50	
5 bushels of corn (grown on farm), at $1	5.00	
44 bushels of oats (grown on farm), at 75 cents	33.00	
55 bushels of cowpeas (grown on farm), at $2	110.00	
		153.50

MISCELLANEOUS.

Bagging and ties for 50 bales of cotton, at 75 cents	37.50
Interest on 66 acres, valued at $100 per acre, at 8 per cent	528.00
Interest and depreciation on machinery, at 18 per cent	71.41
Total cost of crop production	2,855.04

Quantity and value of crops and farm products produced in 1908.

FIELD A.

50 bales of cotton, at $42.50	$2,125.00
25 tons of cotton seed exchanged for 18¾ tons of cotton-seed meal, at $24	450.00

FIELD B.

1,800 bushels of oats, at 75 cents	1,350.00
54 tons of oat straw, at $10	540.00
44 tons of cowpea hay, at $15	660.00

FIELD C.

1,364 bushels of corn, at $1	1,364.00
2¾ tons of pulled fodder, at $25	68.75
Total value of crops produced	6,557.75
Total cost of production	2,855.04
Net value of crops produced	3,702.71

PORK.

4,000 pounds of pork were produced, having a market value of	$320.00	
Estimated cost of production of pork on farm refuse	160.00	
Net proceeds on pork		160.00
Net proceeds from farm		3,862.71

No financial statement of the stock-feeding operations is given, as there are not sufficient data at hand. The owner states that there is a small profit on the feeding and that the manure is produced without cost.

USE OF FERTILIZERS.

Table II gives the total amounts and the cost of fertilizers and manure applied to and the yields of the three cotton crops grown on field A during the period from 1902 to 1908.

TABLE II.—*Comparison of yields of cotton with quantity and cost of fertilizers and manure applied directly to the crop on field A.*

Year.	Fertilizer used per acre.	Manure used per acre.	Cost of fertilizer per acre.	Yield of cotton per acre.
	Pounds.	*Tons.*		*Bales.*
1902	1,375	5	$20.24	1.6
1905	875	5	15.39	2.14
1908	875	7	22.75	2.27

This table shows that the total quantity of commercial fertilizer used per acre in 1908 was 500 pounds, or a little more than 36 per cent, less than in 1902; the amount of stable manure was increased by 2 tons per acre, or 40 per cent. The cost of manure and fertilizer has increased only $2.31, due to increase in market price, while there has been a steady increase in the yield of cotton, amounting in 1908 to a little more than two-thirds of a bale per acre, or 42 per cent, over the yield of 1902. Figure 11 presents graphically the relation to the yields of cotton of the commercial fertilizer used.

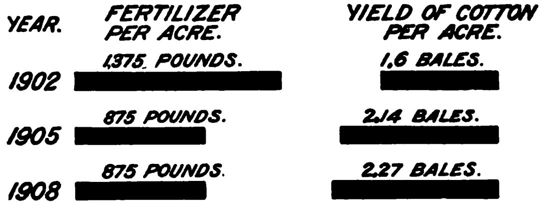

FIG. 11.—Diagram showing the relation of the quantity of commercial fertilizer used to yields of cotton on field A.

This increase in yield with the diminished quantity of fertilizer is to be accounted for very largely by the increased fertility due to the nitrogen-bearing humus furnished by the four cowpea crops intervening between 1902 and 1908 and by the liberal amounts of barnyard manure applied to the soil. Thorough tillage has also undoubtedly played its part.

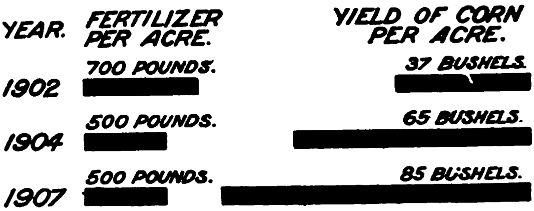

FIG. 12.—Diagram showing the relation of the quantity of commercial fertilizer used to yields of corn on field B.

Figure 12 gives a similar comparison of fertilizer and yield for the three crops of corn grown on field B. This diagram shows a decrease of 200 pounds, or 28½ per cent, in the amount of fertilizer applied to corn from 1902 to 1907, and at the same time an increase in yield of 48 bushels per acre, or about 130 per cent. This is to be accounted for, as in the case of the cotton on field A, partly by thorough tillage and very largely by the cowpea stubble and barnyard manure turned into the soil during the period from 1902 to 1908.

RECOMMENDATIONS REGARDING WINTER COVER CROPS.

It will be noticed that the present system of crop management on this farm—plowing the cotton land for corn in December and plowing the cowpea stubble in November, then furrowing and applying manure for cotton in January—interferes with growing winter cover crops.

In consequence, during two winters out of three the land is without a cover. It is suggested that this winter cover might be accomplished as follows:

After cutting the cowpeas for hay, plow or thoroughly disk the land the last of September or early in October and sow vetch, bur clover, or crimson clover. The vetch or bur clover could be planted at the time of planting the peas and thus save the extra plowing or disking in the fall, for seeds of these crops usually do not germinate until cool weather, while the crimson clover if planted too early is apt to come up and be injured by the hot sun or by drought. Broadcast manure on this winter crop during the winter and turn all under the latter part of February or early March.

Vetch or bur clover might be sown in the cotton at the last working. This would come up at its proper season and form a winter cover. The cotton stalks could be cut down any time during the winter and the land plowed for corn after the cotton land is prepared. The growing of these winter legumes on the land, besides the great benefit to be derived from the humus itself, would so supplement the work of the cowpea in furnishing nitrogen-bearing humus to the soil as to eliminate the necessity of purchasing any nitrogen in commercial fertilizer.

In undertaking a change like this it would be advisable to make it gradually, as it would be necessary to get the soil inoculated for these legumes before they could be grown to best advantage, and that would necessarily take some time to accomplish on a large scale. Also, it would be well to avoid the possibilities of disaster from introducing radical changes on a large scale.

For farms which are so located or equipped that use can not be made of barnyard manure, the growing of legumes, both winter and summer, is strongly advised on account of their great influence on soil fertility by furnishing the soil with nitrogen-bearing humus.

SUMMARY.

The important features to be noted in the management of the farm described are as follows:

(1) The straightening of the field borders, the clearing away of bushes and scrubby trees, the filling of gullies, and the getting of the fields into better shape for cropping operations.

(2) The deep plowing in broad, gently sloping lands, instead of terracing, to control surface water and prevent the formation of gullies.

(3) The deep and thorough system of soil preparation for crops by broadcast plowing and subsoiling.

(4) The adoption and practice of a systematic rotation of crops, including money crops (cotton is the principal money crop), feeding crops (corn, oats, cowpeas), cleansing crops (the clean-cultivated corn and cotton), and a manurial crop (cowpeas), thus providing for the maintenance of soil fertility and for a liberal cash revenue besides the necessary hay and grain for maintaining the work stock and a small herd of cattle and hogs.

(5) The feeding of cattle and hogs for the purpose of converting a part of the grain and roughage of the farm into animal products for sale and into manure for the maintenance of soil fertility.

(6) The building of a cattle shed for the comfort of the stock and for the protection of the manure from leaching rains and burning sun.

(7) The maintenance of and the increase in the supply of humus in the soil by the use of barnyard manure and the plowing in of vegetable material for the control of moisture, plant food, ventilation, and germ life, most important factors of soil fertility.

(8) The application of barnyard manure to the cotton land in a rotted and moist condition, covering it immediately two or three months before planting, and the thorough mixing of the manure with the soil before putting in the crop, thereby diminishing, if not entirely eliminating, the tendency of the crop to "burn," which often occurs in dry seasons when the crop is planted on recently applied coarse manure.

(9) The greater space given each individual cotton plant as the soil became more fertile and the plants grew larger, thus giving room for large, well-branched, heavily fruited plants.

(10) The closer planting of the more slender growing corn as the soil became more fertile, thus insuring a greater number of stalks to the acre and increasing the possibility of securing larger yields.

(11) The immediate good results the first year of the present management indicated by yields of 1½ bales of cotton per acre and 37 bushels of corn per acre, as compared with previous yields of 300 pounds of seed cotton and 5 to 8 bushels of corn per acre.

(12) The continued increase in crop yields accompanying a decrease in the amount of commercial fertilizer used, the cotton yield increasing from 1.6 bales per acre in 1902 to 2.27 bales per acre in 1908 with 500 pounds less of commercial fertilizer, the corn yield running up from 37 bushels in 1902 to 85 bushels per acre in 1907

with 200 pounds less of commercial fertilizer, and the oat yield increasing from 10 bushels per acre with 150 pounds of commercial fertilizer in 1902 to 80 bushels per acre in 1908 without a pound of commercial fertilizer.

(13) The substantial and gratifying financial returns.

SOME FEATURES OF THE SYSTEM OF MANAGEMENT DESCRIBED APPLICABLE TO MANY FARMS.

While the system of managing this farm could be carried out in detail on comparatively few other farms, one or more of the main features of the system are applicable to nearly every farm in the cotton belt.

Crop rotation can be introduced with advantage on every farm not already practicing it. On nearly every farm it would be economical to grow the grain and forage necessary for home consumption, and it would be profitable to grow some for market also. Some form of stock raising, dairying, mule raising, or cattle feeding could be made at least self-sustaining and indirectly profitable through its influence on soil fertility.

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Issued September 2, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 365.

FARM MANAGEMENT IN NORTHERN POTATO-GROWING SECTIONS.

BY

LAWRENCE G. DODGE,

Scientific Assistant, Office of Farm Management,
Bureau of Plant Industry.

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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 6, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Farm Management in Northern Potato-Growing Sections," prepared by Mr. Lawrence G. Dodge, of the Office of Farm Management of this Bureau, and to recommend its publication as a Farmers' Bulletin.

This manuscript deals with the potato crop as a part of a system of farming, and gives special attention to the system of farming prevailing in Aroostook County, Maine, where potato growing is perhaps more highly developed than in any other section of the United States.

It is hoped to publish later bulletins giving specific instructions for the growing of potatoes in various sections of the United States.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 5
    Statistics of potato growing in the United States 6
    Importance of the potato crop in the Northern States 6
Methods employed in growing potatoes in Aroostook County, Maine 7
    Yield 7
    Markets 7
    Climate, soil, etc 8
    Rotation of crops 8
    Planting 8
    Cultivation 10
    Spraying 11
    Digging 12
    Use of machinery 13
    Storage 13
    Profits 14
    Importance of clover in the rotation 14
    Careful cultivation the keynote of success 15
Methods employed in growing potatoes in other sections 16
    Potato growing in central and southern Maine 16
    Potato growing on Long Island 16
    Potato growing in western New York 18
    Potato growing in Michigan and Wisconsin 18
    Various means employed in handling the crop 20
Cost of producing potatoes 20
Problems confronting Aroostook County growers 22
    Maintenance of soil fertility 23
    Application of barnyard manure 24
    Protection from scab 25
    Rotation with clover for seed 25
Seed selection 26
    Selection by hills 26
Conclusions 28
    Soils adapted to potato growing 29
    Importance of rotation of crops 29
    Use of commercial fertilizers 29
    Application of barnyard manure 29
    Necessity for thorough cultivation of the crop 29
    Spraying to prevent blight 30
    Machinery desirable 30
    Marketing the crop 30
    Maintaining a supply of humus in the soil 30

ILLUSTRATIONS.

Page.
FIG. 1. Map of the northeastern portion of the United States, showing the ten leading potato-growing States and their production of potatoes in million bushels in 1908 5
2. Potato planter of the picker type 9
3. Potato planter of the type operated by two men 9
4. Horse hoe and hilling attachment on a sulky cultivator used at Caribou, Me 10
5. Tank for hauling spraying mixture to the field, with a two-horse sprayer in the rear 11
6. Digging potatoes near Caribou, Me., showing the heavy elevator digger and the low-down wagon used 12
7. Potato storage cellar at Limestone, Me 14
8. Potato digger of one of the simplest types 20
9. Sorting potatoes in the field over a portable screen 21
10. Pit used for storing potatoes in the field, near Greenville, Mich 22
11. Individual hills of potatoes as they grew in the field, with good and poor hills close together 27

B. P. I.—479.

FARM MANAGEMENT IN NORTHERN POTATO-GROWING SECTIONS.

INTRODUCTION.

The white potato, often known as the Irish potato, is grown to some extent in every State in the Union. It plays an important part in farming, however, in the Northern States only, and throughout the North when the word "potato" is used it refers to the white potato. The leading potato-growing States of the country, those where the crop is at home and where it forms an important farm crop, are the two northern tiers of States east of the one hundredth meridian. (See fig. 1.) Besides this region there are several States growing large quantities of potatoes, but not at all comparable with the district mentioned.

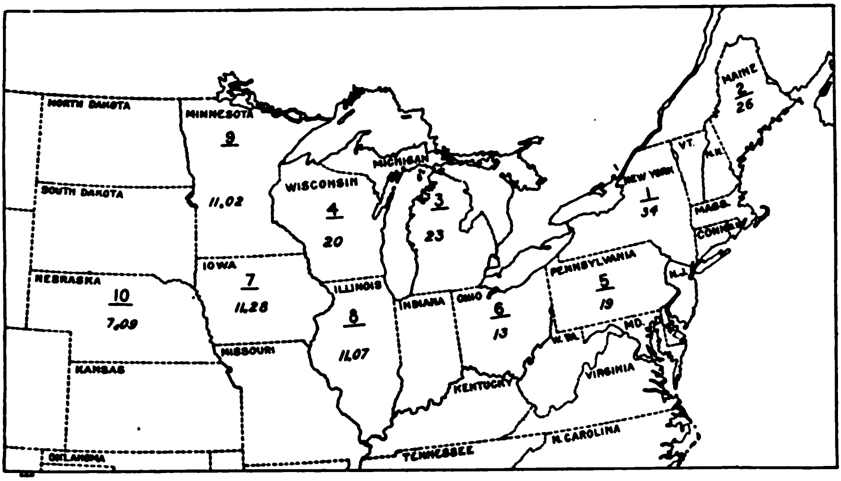

FIG. 1.—Map of the northeastern portion of the United States, showing (the order of production being underlined) the ten leading potato-growing States and their production of potatoes in million bushels in 1908.

There are several States along the Atlantic and Gulf coasts where potatoes are an important crop, but in those States they must be reckoned as truck crops in the majority of cases rather than as a general farm crop. In the Western States the white potato figures largely as an irrigated crop, but on account of the restricted localities where irrigation is possible here again the potato crop must be reckoned as a specialized industry.

It is not the intention in this bulletin to treat of specialized potato growing such as occurs on truck farms or in irrigated sections further than to refer to it in its relation to the crop as grown in the ten leading States.

STATISTICS OF POTATO GROWING IN THE UNITED STATES.

The production of potatoes in the ten leading potato-growing States in 1908, together with their total acreage and average yields per acre, is presented in the following table:

TABLE I.—*Production of potatoes in each of the ten leading potato-growing States of the United States in 1908, with total area planted and average yield to the acre for the year specified and for ten years, compared with the same statistics of production for the United States as a whole.*

State.	Area planted in 1908.	Average yield to the acre in 1908.	Average yield to the acre for ten years.	Total production in 1908.
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*
New York	425,000	82	85	34,850,000
Maine	116,000	225	177	26,100,000
Michigan	325,000	72	84	23,400,000
Wisconsin	252,000	80	91	20,160,000
Pennsylvania	277,000	72	83	19,944,000
Ohio	170,000	77	81	13,090,000
Iowa	141,000	80	83	11,280,000
Illinois	156,000	71	85	11,076,000
Minnesota	145,000	76	86	11,020,000
Nebraska	91,000	78	84	7,098,000
Total in ten States	2,098,000	84.8	89.2	178,018,000
Total in all the States and Territories of the United States	3,257,000	85.7	90	278,965,000

A glance at this table shows that the average yield in Maine, 225 bushels per acre, is considerably more than for any of the other nine States, while no other State of the ten here listed shows an average yield for 1908 of more than 82 bushels. These conditions are not peculiar to the extreme season of 1908; the average yield for the past ten years shows that the production per acre in Maine is nearly twice that of any of the other nine States enumerated, though there does not seem to be sufficient difference in the climatic or other natural conditions to account for this wide variation.

IMPORTANCE OF THE POTATO CROP IN THE NORTHERN STATES.

The potato crop holds the most important place in the general farming of the Northern States as a whole in point of cash returns to the acre. The potato not only thrives best in the cool climate of these States, but at the same time is very productive where the climate almost forbids corn growing. Consequently, in those Northern States where live-stock farming predominates the potato is likely to be the one crop grown to sell, all the other crops being fed to stock.

In many localities in these Northern States the potatoes are all consumed near the place of production, but through those States as a whole the crop is grown in such quantities as to be shipped extensively to other parts of the country. They are not only sent by the carload and boatload into the large cities both at the North and South, but from these States is shipped the supply of seed stock required by those sections of the South where early potatoes are grown as a truck crop. Some of those southern localities demand new seed from the North every year, and all of them are compelled to renew their seed at frequent intervals. On the Gulf coast, for instance, seed grown in the North the previous season will usually produce a crop from one to two weeks earlier than seed which has been grown in the South even for one year.

METHODS EMPLOYED IN GROWING POTATOES IN AROOSTOOK COUNTY, MAINE.

YIELD.

In view of the various yields of potatoes in the different States it seems worth while to inquire into the reasons for the high standard of potato culture in Maine. The largest potato-growing county in the United States is Aroostook, in the northernmost part of Maine, and in fact the northernmost part of the United States east of the Great Lakes. While potatoes are grown to some extent over the southern and western parts of Maine, the great bulk of the crop for the State is produced in this one county, probably 18,000,000 or 20,000,000 bushels out of the 1908 crop being grown there. From careful observation of the growing of the potato crop in Aroostook County it appears that the yield there averages about 275 bushels (100 barrels) per acre.

MARKETS.

Aroostook County has no special market advantages for disposing of its crop, but, on the contrary, is some 350 miles or more by rail from Boston and more than 100 miles from tidewater. From Houlton, which is at the nearer or southern end of the section, freight to New York by rail amounts to 42 cents a barrel (165 pounds), and as potatoes are frequently put up in barrel sacks costing 10 cents apiece, the expense for each barrel amounts to 52 cents. From other towns farther north the freight is still more. The greater part of the year is required to ship all the potatoes out of that locality, shipping usually commencing the latter part of August and lasting until late in June.

CLIMATE, SOIL, ETC.

The climate of Aroostook County is cold, with a short growing season, the effect of which is probably felt more in hindering the successful production of other crops than in the advantage to the potato crop. The soil is in general a friable loam containing a good many loose, small stones, and though the general character of the soil is said to be quite similar over the surrounding territory, potato growing is mainly confined at present to a strip of country some 25 miles wide and perhaps 100 miles long near the New Brunswick border, the remaining portion of similar land still being a lumbering section. The upland, which was formerly covered with beech and maple forest, is the most suitable for potato growing, for it is naturally well drained. The rainfall is heavy and the drier seasons are the most prosperous ones for the potato growers.

ROTATION OF CROPS.

The general methods of potato culture in use have developed during the past fifteen years, or a little more, and are followed with considerable uniformity throughout the section. The rotation is a simple one, but is undoubtedly the foundation of the success of the growers. Potatoes are grown on any piece of land only one year as a rule and are followed by one crop of oats or spring wheat, with which are sown clover and timothy for hay. This crop is cut for hay one year by many of the best farmers and plowed in the fall for a new potato crop. The furrow is usually turned to a depth of 7 or 8 inches, and on most of the farms this work is done with a reversible sulky plow, an implement admirably adapted to working on sidehills. Some growers like their hay fields to stand a second year before plowing, but rarely longer than that, for the land is in too much demand for potatoes to continue it in grass more than two years.

The sod, usually containing a large amount of clover which was plowed the previous fall, is harrowed in the spring as soon as the season permits, usually being worked over thoroughly four times in all with a disk harrow followed by a spring-tooth harrow.

PLANTING.

Planting is done from the 15th or 20th of May to the 1st of June, using about 5 barrels of seed to the acre; that is, 13 or 14 bushels. The seed is cut by hand into pieces containing about two eyes and of such a size as to feed readily through a planter, and is dropped by the planter in rows about 33 inches apart and from 12 to 15 inches apart in the row, so that the ground is entirely occupied with the crop and the vines in midseason meet in the rows.

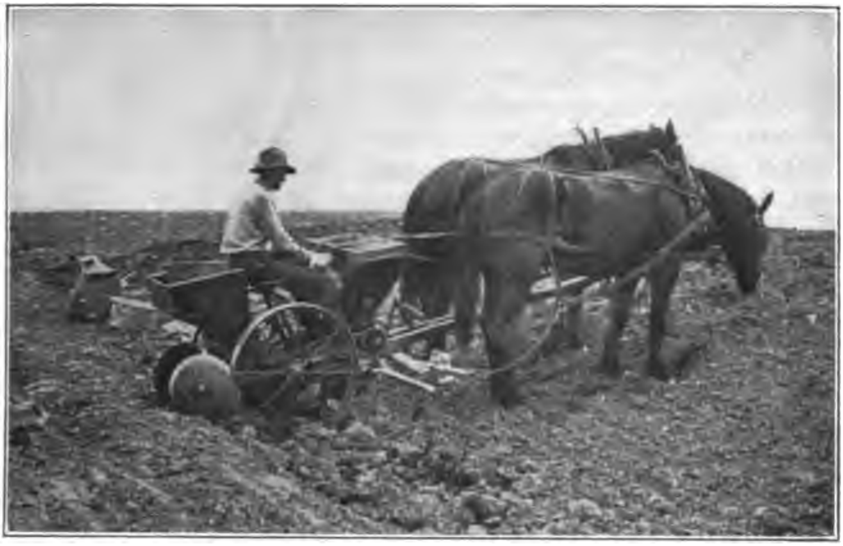

FIG. 2.—Potato planter of the picker type.

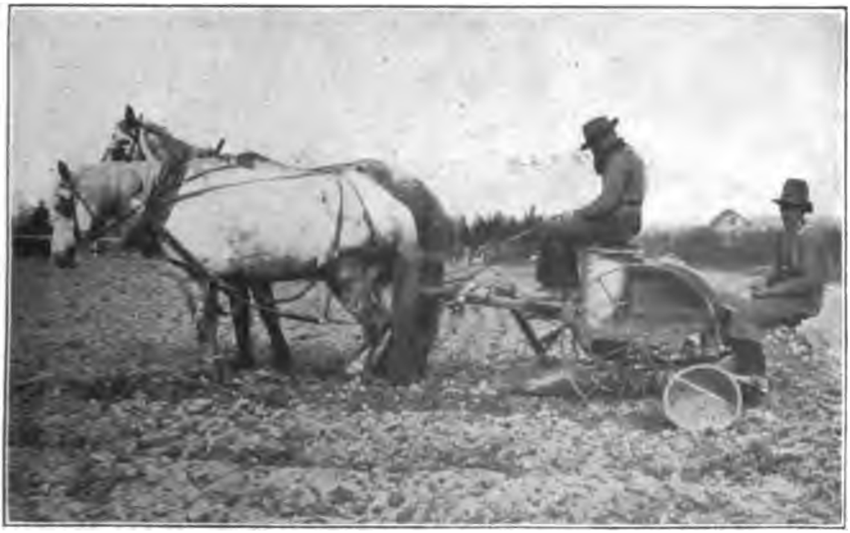

FIG. 3.—Potato planter of the type operated by two men.

There are two prevailing types of planter, in one of which the seed pieces are distributed by steel forks or pickers and in the other by pockets in a revolving disk. Both types are two-horse machines, the former being operated by one man and the latter requiring a second man to attend to the seed distribution, but insuring a more perfect stand. Either type will plant about 5 acres per day. (See figs. 2 and 3.) The planter at the same time distributes the fertilizer, from 1,200 to 1,500 pounds per acre usually being applied. This amount of fertilizer can be safely used directly in the drills. The fertilizer commonly used contains about 3 per cent of nitrogen, 7 or 8 per cent of phosphoric acid, and 9 or 10 per cent of potash.

CULTIVATION.

About the time that planting is finished the larger grower usually commences cultivation on the first-planted portions of the field. A horse hoe is most frequently used the first time, following the row either by the plants which are just appearing or by the slight ridges left by the planter. The rows are hilled up sufficiently to cover any potato plants which may have appeared. This is usually followed by a cultivator, some type of the two-horse riding cultivator being most commonly used. This operation commences about a week or ten days after the beginning of the first working, often as soon as the whole crop can be worked over once with the horse hoe. This treatment is usually kept up with the cultivator and horse hoe, alternating until the vines nearly cover the ground, at some time in July, usually calling for six or seven cultivations, ending with the horse hoe or some appliance to take its place in ridging up the rows. (See fig. 4.) This turning of the loose soil upon the potato row has proved most effective in checking the growth of weeds in the row, and is usually

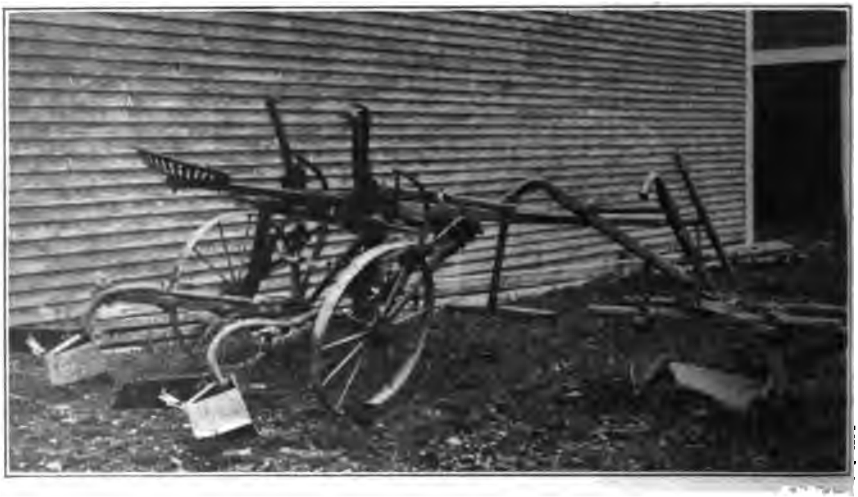

FIG. 4.—Horse hoe and hilling attachment on a sulky cultivator used at Caribou, Me.

relied upon to accomplish that result, since hand hoeing is out of the question when one farmer has 50 or 75 acres of potatoes, as frequently is the case.

SPRAYING.

Usually before the cultivating is finished, spraying the crop has commenced. Bordeaux mixture for the prevention of blight, with Paris green or some other arsenical preparation added to kill the potato beetles, is applied from a sprayer cart drawn by either one or two horses, with power applied from the wheels for driving the pump. (See fig. 5.)

Copper sulphate or blue vitriol and quicklime are used at the rate of 6 pounds of each to 50 gallons of water. The lime is best slacked in one tank or barrel, the blue vitriol dissolved in another, and each is usually diluted until the whole quantity of water is used before they are mixed. These proportions are safe only when the lime is new and of full strength, and when there is any doubt about the strength of the lime a safer proportion is 5 pounds of blue vitriol to 6 pounds of lime. About 50 gallons of the solution are applied to the acre, and at the first spraying of the season a pound of Paris green for each acre is added to the Bordeaux mixture. Once, later in the season, Paris green is applied in the same way to kill the second brood of beetles. The use of Paris green in this way has proved very effective, so much so that the beetles are much less troublesome than

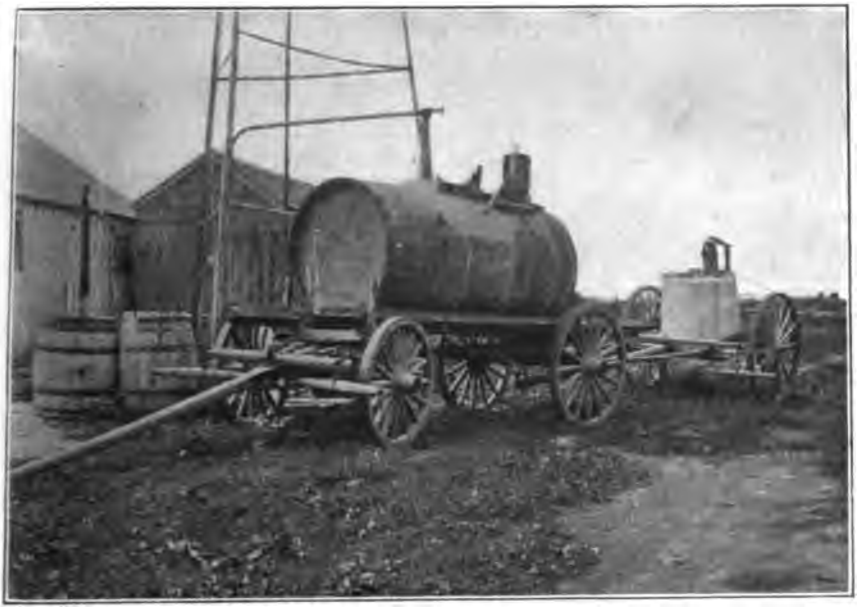

FIG. 5.—Tank for hauling spraying mixture to the field, with a two-horse sprayer in the rear.

they were a few years ago. In the opinion of some of the leading potato growers the principal requisite in applying Bordeaux mixture is to have on the spraying apparatus a pump of sufficient capacity to produce a very fine, mistlike spray which will drift all through the mass of growing vines in the row and settle upon all parts of the foliage. Spraying is done from three to five times during the growing season, and is considered an absolute necessity for a successful crop, so that very few potato growers in Aroostook County think of doing without spraying their crops for prevention of blight.

DIGGING.

The Green Mountain is the principal variety of potato grown in Aroostook County, but the Irish Cobbler and one or two less important early varieties are grown to some extent. Some of the earlier ones are ready to dig about August 20 or 25.

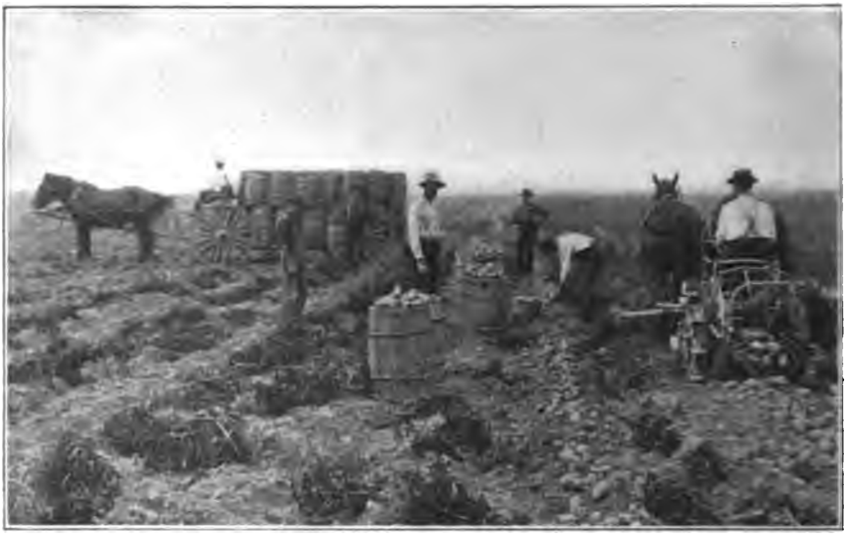

FIG. 6.—Digging potatoes near Caribou, Me., showing the heavy elevator digger and the low-down wagon used.

Digging usually is carried on with only short interruptions from about the 20th of August until the middle of October, when it is usually necessary to have all the crop dug and stored on account of freezing weather. The great bulk of the crop is dug between September 20 and October 10.

The crop is dug entirely by machine, one of the large, heavy elevator diggers being found necessary. (See fig. 6.) This work requires either two or four horses, according to the condition of the land. The digger will usually turn out about 3 acres a day, and from seven to nine pickers are required to keep up with it. This is about the only hand labor required, since the crop is worked entirely by machine from the time the seed is ready for the planter until the potatoes are turned out of the ground and lie ready for picking up. Not only is hand work limited to these two operations, but for the major part of the machine work the man is not required to walk. This plan of operations involves considerable expenditure for machinery, but enormously increases the efficiency of one man.

USE OF MACHINERY.

Mr. J. M. Ward, of Limestone, Me., enumerates the necessary machinery for potato growing as follows:

2 sulky plows	$100
2 spring-tooth harrows	25
1 planter	65
1 2-row riding cultivator	45
1 horse hoe for hilling	10
1 4-row sprayer	65
1 digger	100
Total	410

This equipment, with the addition of one wagon of the type known as a jigger (see fig. 6), is operated by two men and four heavy horses. The two men with this equipment are able to prepare for, plant, and handle 50 acres of potatoes up to digging time, when they require six or seven day hands to pick up the potatoes. This, of course, is an expensive equipment compared with that formerly used on the potato crop, which was as follows:

1 walking plow	$15
1 harrow	15
1 horse hoe	10
Hand hoes	3
Total	43

Without question the additional outlay increases the acreage which two men can handle just about in proportion to the increase in cost.

STORAGE.

Most of the farmers have potato houses or cellars constructed for storing their stock and holding the unsold portion of the crop through even the coldest weather until they can market it. Some growers, especially those near town, depend on the warehouses of the dealers alongside the railroad tracks. The common type of storehouse on the farm is a cellar walled up with concrete or stonework, about 8 or 9 feet deep, with a low wooden roof above it, giving a considerable space for the storage of tools, barrels, etc., on the floor above the cellar portion. (See fig. 7.) These cellars are usually built on the side of a hill, so that the potatoes are unloaded down through the floor in the fall and taken out at a lower doorway during the winter.

PROFITS.

The crop has been averaging for the past few years a price of $1 per barrel, or a little better, to the farmer at the shipping station, and at that rate proves a very profitable crop, for it is estimated to cost from $50 to $60 an acre to grow 100 barrels, counting in the cost of labor, seed, fertilizer, and rent of land. Although this would indicate a profit of from $40 to $50 per acre, or perhaps a little more, it must be remembered that this crop is produced not oftener than every third year on a given piece of land, and in the interim the grain crop and hay crop will pay no such profits, although the yields of both are good and their production is well worth while. On many potato farms of Aroostook County much of the hay and grain is sold, usually to the logging camps in the lumbering country quite close at hand.

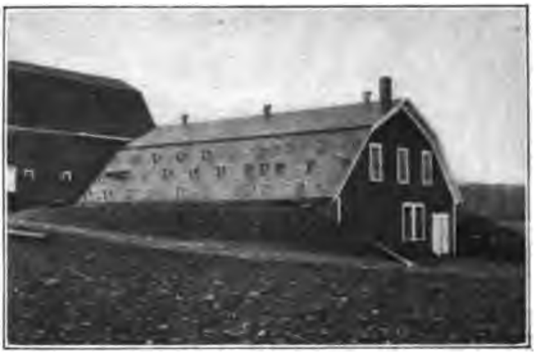

FIG. 7.—Potato storage cellar at Limestone, Me.

IMPORTANCE OF CLOVER IN THE ROTATION.

One frequently finds large farms of 200 or 300 acres, having perhaps 200 acres of tillable land, on which are kept only sufficient horses for handling the crops and one or two cows for the home supply of milk and butter. With so few live stock from which manure may be obtained, it is reasonable to conclude that the rotation involving a crop of clover on which to grow the potato crop is an essential. On some of the older farms, where oats and hay had been grown for a long term of years, the present system has done much in the last twelve or fifteen years to improve the condition of the land. It is often claimed that under the present system, even without barnyard manure, the land is gradually improving. So long as the clover crop is a success on these farms the system bids fair to prosper. If for any cause, however, the clover crop should cease to be successful, the prospects of this system of farming would be seriously injured.

When land located near a town is renting at from $14 to $16 an acre for one year for the purpose of growing a crop of potatoes, men who hire such land are often willing to pay $2 an acre more if the land has a good clover sod on which to plant their crop than if it has merely an old grass sod.

CAREFUL CULTIVATION THE KEYNOTE OF SUCCESS.

As further evidence that successful potato culture, even in Aroostook County, is largely due to the treatment of the crop, some experience with individual fields may be quoted.

Of a number of acres of potatoes grown at Houlton, Me., one season recently, a part of the field was harrowed twice with a spring-tooth harrow; the rest of it was harrowed thoroughly four times, twice with a disk and twice with a spring-tooth harrow. In all other respects the two portions of the field were treated alike. The crop on the portion which received the less harrowing averaged 80 barrels per acre and that on the thoroughly harrowed part 100 barrels per acre.

Again, on a small field of 3½ acres in the northern part of Aroostook County the crop was cultivated fourteen times during the season of 1904. The land had previously been handled for several years in an excellent manner as regards rotation and tillage. In an adjoining field on very similar land another farmer raised 6½ acres which received two cultivations for the season, once with a cultivator and once with a horse hoe. The latter field had received less careful management in previous years. In other respects the two lots differed little in treatment. The yield on the first was 140 barrels per acre, or 490 barrels on 3½ acres. The yield on the second was 70¾ barrels per acre, or 460 barrels on 6½ acres—30 barrels less in all than on the smaller lot.

The thorough and frequent working of the land for the potato crop has accomplished another result. When the present system of potato culture was commenced in northern Maine, witch-grass, or quack-grass, threatened the success of the business most seriously. At the present time this weed is one of the least serious difficulties to be overcome. Thorough working of the land occupied with a potato crop is part of the solution for this problem. This includes especially the work of the potato digger, for it shakes loose from the row any witch-grass roots which may have escaped the cultivation of the early season. A short rotation is another factor tending to the extermination of witch-grass by giving little opportunity for it to occupy the land.

METHODS EMPLOYED IN GROWING POTATOES IN OTHER SECTIONS.

As an indication that the success of these potato growers is not by any means largely due to their local conditions, it is well to note the success of potato growing according to similar methods in other localities.

POTATO GROWING IN CENTRAL AND SOUTHERN MAINE.

In central and southern Maine, where the land has been considered unsuited to potato growing and is valued at from $25 to $40 an acre, in contrast with the $80 and $100 land of Aroostook County, the same methods have been applied with equal success. One often hears of Aroostook County farmers who have sold their expensive land in the northern part of the State and are buying cheaper farms in the southern counties.

On the farm of W. J. Thompson, in Kennebec County, Me., 10 acres of potatoes were grown according to the Aroostook system in 1907, that method being followed throughout in culture, in the application of fertilizer, and in spraying. All the labor of men and teams was hired at current prices. The total cost of 10 acres for labor, seed, fertilizer, and spraying materials, including the hauling of the potatoes to market, was $754, of which $144 was for transportation to market. The land used was old, run-out fields and pasture, and no barnyard manure was applied. There was a yield from 10 acres of 1,800 bushels of market potatoes, which sold at 72 cents, bringing $1,296, a profit of $542 on the 10 acres. This farm was located some 200 miles nearer the large markets than is Aroostook County, and accordingly the better price for the crop made up for the lighter yield. To raise 18 acres of oats, following the potatoes of the previous year, cost $216 for labor and seed, but with no additional fertilizer. The oats yielded 40½ bushels per acre, or 730 bushels in all, which sold at the farm for 60 cents a bushel, amounting to $438, and 13 tons of straw, valued at $4 a ton, giving a profit on the 18 acres of $274, or of $222 on the grain alone. A good stand of clover was also obtained that year and the previous year, the clover-mixed hay yielding at least 1½ tons per acre in 1907, having been seeded with oats the year before. These figures would indicate that on a good clover sod, such as is now becoming available on this farm, as large yields of potatoes can be obtained as are common in Aroostook County.

POTATO GROWING ON LONG ISLAND.

Some variations of the Aroostook plan are employed in numerous other places. On Long Island, for instance, in the truck-growing section very similar methods are employed. The one different feature worth noting seems to be that level cultivation is the general rule on Long Island. Aside from this, the milder climate of Long Island allows the use of crimson clover. Although that crop is not hardy enough to survive the average Long Island winter, the experience of one farmer there has shown that when sown in August, following rye, it will make sufficient growth before winter to be worth while plowing under the following spring for potatoes, and this allows a crop of potatoes every other year and a crop of winter rye, usually profitable for the straw, in the intermediate year. The level cultivation on Long Island is due mainly to the difference in the supply of available moisture. In northern Maine the method of hilling previously described is frequently necessary to keep superfluous surface water away from the potato plants. On Long Island level culture is utilized to help retain the available supply of moisture in that region of more sandy soil and less abundant rainfall. There, instead of using the horse hoe to any extent, the early cultivation of the potato crop is done almost wholly with the weeder, this implement being used sometimes three times, or continuously until the plants are 5 or 6 inches high. From that time on the crop is worked with a cultivator, and any attempt to hill up the rows is avoided.

Spraying with Bordeaux mixture is practiced in the same manner as in Aroostook County. In addition many potato growers on Long Island are using the formaldehyde treatment on their seed potatoes to reduce the damage from scab. This disinfection is usually accomplished by soaking the seed potatoes for an hour and a half in a solution of 1 pint of formaldehyde to 30 gallons of water. The soaking is done before the seed is cut and then the seed is spread out to dry. In this way the fungus which causes most of the scabby potatoes, in the East at least, is destroyed so far as the tubers are concerned, and the seed potatoes are considered to be one of the chief means of spreading this disease. To do this work more rapidly where large quantities of seed are to be treated the seed may be spread on racks and fumigated with formaldehyde gas. For this purpose the racks should be arranged as compactly as possible in a room which may be tightly closed so as to prevent the escape of any of the gas. When the potatoes are all in the racks, 23 ounces of potassium permanganate for each 1,000 cubic feet of space in the room should be spread thinly in shallow pans, and over this 3 pints of formaldehyde should be poured. The room should be closed at once and allowed to remain closed for twenty-four hours.[a]

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[a] For a more detailed account of this method of treatment, see Circular No. 23 of the Bureau of Plant Industry or Bulletins Nos. 141 and 149 of the Maine Agricultural Experiment Station.

POTATO GROWING IN WESTERN NEW YORK.

Potato-growing methods similar to those described in Aroostook County are employed by numerous planters in western New York on rather heavy soils containing gravel or clay loam, and even where considerable underdraining has proved necessary. Mr. T. E. Martin, of Monroe County, N. Y., has raised 18 acres of potatoes each year on such a heavy soil, all of which it was necessary to underdrain. With a three-year rotation of wheat, clover, and potatoes, fertilized with 1,600 pounds of home-mixed fertilizer, he has grown an average of more than 300 bushels to the acre, and in 1906 raised an average of 417 bushels on the 18 acres. He employs thorough cultivation and thorough spraying with Bordeaux mixture.

Another potato grower in western New York, Mr. J. D. Taylor, of Steuben County, has had repeated success in growing potatoes without commercial fertilizer, using a three-year rotation and stable manure. He gets one crop of hay in the year following the wheat crop, and soon after mowing spreads 20 loads of light, strawy manure per acre on the stubble. He lets the second crop grow up through this and fall down. The whole is then plowed under late in March or early in April and planted to potatoes a month later after thorough preparation. No commercial fertilizer is applied, and with the variety of potato known as Sir Walter Raleigh the usual yield is from 250 to 300 bushels to the acre.

In general it has been found exceedingly profitable in any part of the State of New York to spray potatoes with Bordeaux mixture as a preventive of blight. A series of experiments carried on by the Geneva Agricultural Experiment Station in cooperation with numerous farmers scattered over the State showed an average gain of 50⅕ bushels to the acre for spraying. The average net profit from a series of five years of business experiments carried on by the Geneva station in cooperation with numerous farmers was $19.86 per acre. The average gain in yield for six years in experiments with spraying every two weeks carried on at the Geneva station was 121⅗ bushels. A similar series of experiments carried on by the substation on Long Island under drier climatic conditions showed an average gain of 60½ bushels. This seems to be conclusive proof that the use of Bordeaux spray in preventing loss from blight is a thoroughly profitable proposition in a climate either like that of central New York or of Long Island, where less rain prevails.

POTATO GROWING IN MICHIGAN AND WISCONSIN.

In Michigan the prevailing practice is to use commercial fertilizers sparingly or not at all. The seed is usually planted farther apart, often being check-rowed 34 or 36 inches apart each way, and the work throughout the season is usually done on a less expensive scale than in Maine. There are, however, numerous farmers who get yields much heavier than the 150 bushels, more or less, so commonly grown by the cheaper methods.

One grower who keeps considerable live stock, both cattle and sheep, always plants potatoes on a clover sod which has been pastured by sheep one season after being seeded with grain the previous year. This sod receives a light application of sheep manure during winter after the grain is cut, or perhaps during the summer when it is being pastured. Without commercial fertilizer, with the crop check-rowed 34 inches each way and thoroughly cultivated in both directions, and with the best of seed, more than 200 bushels to the acre are obtained.

A grower in central Wisconsin who keeps a considerable flock of sheep and plants seed taken from the best-yielding portions of his field only has maintained a yield of about 200 bushels an acre, a point which his neighbors who have less live stock and plant cull potatoes have been unable to attain. According to some of the most successful potato growers in Wisconsin the land there is falling off in its potato production even when clover sod is available, but wherever live-stock raising is being introduced and a supply of barnyard manure becomes available the crop is much larger. An application of 15 loads of barnyard manure per acre, each load weighing a ton to a ton and a half, has been shown to approximately double the potato crop, and when carefully applied—that is, not immediately before potato planting—has shown no bad results in causing scabby potatoes. In central Wisconsin dairy cattle and the use of silos seem to be increasing, and as this type of farming comes in, involving a more rapid crop rotation upon the land and the return of humus to the soil by means of barnyard manure at the same time, the potato yields promise to increase steadily.

Commercial fertilizers are still more in general distrust by the majority of potato growers in Wisconsin than by those in Michigan, but it is very probable that a judicious use of commercial fertilizer containing a high percentage of potash could be profitably employed by these men in connection with available manures and clover sod.

Spraying with Bordeaux mixture for blight is generally considered unnecessary in Michigan and Wisconsin, but the experience of growers who have used this mixture indicates that its use would result in sufficient gain in yield when the blight is severe to pay a handsome profit on the cost of spraying every year. For instance, in Van Buren County, Mich., on the farm of Mr. Jason Woodman, the portion of the potato crop in 1907 which was carefully sprayed with Bordeaux mixture produced a yield of 263 bushels per acre, and the unsprayed rows at the rate of 168 bushels per acre. Where horse spraying outfits are employed to apply Paris green to the potato crop it would be very little added expense to use Bordeaux mixture at the same time and so protect the crop from blight.

VARIOUS MEANS EMPLOYED IN HANDLING THE CROP.

In other sections of the potato-growing States different means are employed with certain parts of the handling of the crop. On some of the sandy loam soils fairly satisfactory work is done in digging by the use of a simple plow digger, such as is shown in figure 8. In some of the more western localities the crop is sorted in the field with the aid of a screen which is dragged along the field. (See fig. 9.) In those same sections a rough dugout takes the place of more expensive cellars. In some parts of Michigan and Wisconsin the crop is stored in pits in the field until it can be marketed, but has to be shipped or taken to some permanent storage before winter sets in. These pits are made by merely digging off the surface soil to the depth of a foot or a little more, then piling in the potatoes to perhaps 3 feet above the surface of the ground. After that they are covered with a layer of straw, and then with the loose soil that was dug off at first. (See fig. 10.)

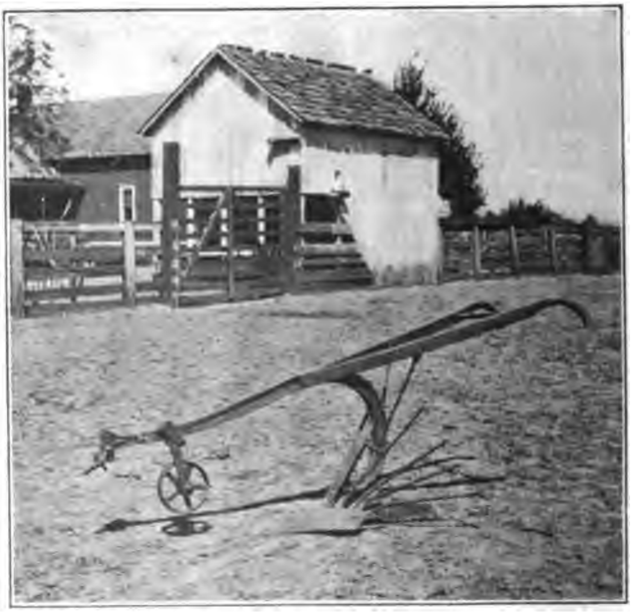

FIG. 8.—Potato digger of one of the simplest types.

COST OF PRODUCING POTATOES.

The following table represents the usual expense of growing an acre of potatoes in Aroostook County, Me., and in many parts of Michigan and Wisconsin. In fact, the second column of figures will represent the expense put into growing the crop in most localities where potato growing is carried on on a less expensive and thoroughgoing basis.

TABLE II.—*Cost of producing 1 acre of potatoes in Maine and in Wisconsin.*

Cost of supplies and labor, with rent of land.	Maine.	Wisconsin.	Cost of supplies and labor, with rent of land.	Maine.	Wisconsin.
Plowing	$1.50	$1.25	Cultivating	$3.50	$1.90
Harrowing	.50	.25	Spraying	3.00	[a].80
Fertilizer	24.00	....	Digging	6.00	2.10
Seed	5.00	2.50	Rent of land	15.00	5.00
Cutting	.75	.60			
Planting	.75	.60	Total	60.00	15.00

[a] For beetles only.

The more expensive method of growing potatoes usually gives a yield of 275 bushels or more to the acre. Unless an application of barnyard manure is made in addition to the expense estimated, at an added cost of from $5 to to $10 per acre, the less expensive method rarely produces more than 125 bushels per acre and in a great many instances decidedly less than 100 bushels per acre. The increase in yield as a result of the more costly method is sufficient to more than pay the difference in cost, supposing potatoes to sell as low as 33⅓ cents a bushel. One hundred and twenty-five bushels per acre grown at a cost of $15 per acre and sold at 33⅓ cents per bushel yield a net profit of $26.66 per acre. Two hundrd and seventy-five bushels per acre grown at a cost of $60 per acre and sold at 33⅓ cents per bushel yield a net profit of $31.66 per acre. The second profit is $5 more per acre than the first.

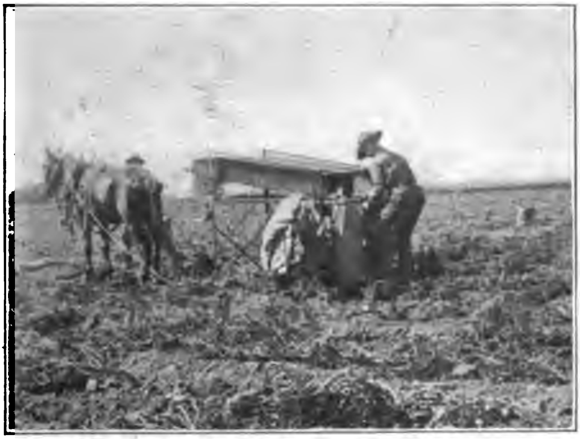

FIG. 9.—Sorting potatoes in the field over a portable screen.

A farmer in Van Buren County, Mich., states that his potato crop, mostly marketed in the fall, sold at an average price of 44 cents a bushel for a period of ten years. At the latter price the more expensive method of culture would yield a profit of $61 per acre, against $40 from the cheaper method. Furthermore, some of the leading potato dealers of the North have stated emphatically that a better quality of potatoes is normally obtained with large yields than with small.

PROBLEMS CONFRONTING AROOSTOOK COUNTY GROWERS.

Although the present system of potato growing in Aroostook County is proving fairly profitable to the growers, one is forced to ask how long this condition will exist before the clover crop becomes less dependable. This question arises when one considers the results that have come to other sections where a similar system of farming, involving little or no live stock, has been followed. When mixed clover hay is sold to the logging camps at $8 or $9 a ton, as has frequently been the case in Aroostook, it is questionable how much profit is to be had by curing the hay crop and selling it at such prices. At the usual price for commercial fertilizers a ton of clover hay contains something like $9 worth of nitrogen, phosphoric acid, and potash. Accordingly, a few of the most successful potato growers do not try to make hay when it will interfere with giving proper care to tilling or spraying their potato crop. They have found it more profitable to spend all the time necessary in caring for the potato crop and then to cut and cure only so much hay as time will allow. Then if time is not sufficient for curing their whole hay crop some

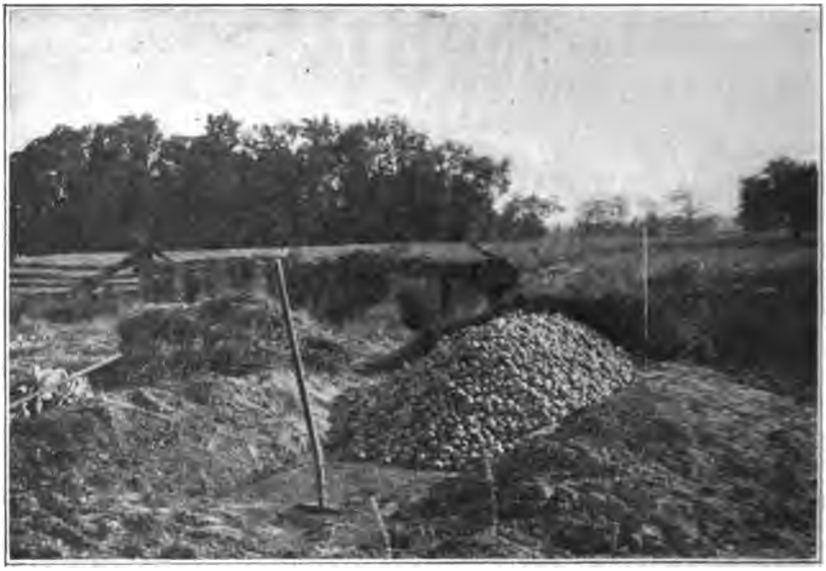

FIG. 10.—Pit used for storing potatoes in the field, near Greenville, Mich.

of the fields are mowed and the grass allowed to lie on the ground until time to turn the sod under for the next year's potato crop.

In the particularly rainy season of 1907, when the crop fell way below the average in Aroostook County, Mr. D. D. Powers followed such a plan as this and let a large number of acres of hay go to waste so far as the hay was concerned. Mr. Powers, however, harvested a crop of potatoes which was about 90 per cent of a normal yield, while several of his neighbors who neglected the care of their potatoes during the summer in order to cut their hay harvested that fall only about 70 per cent of a crop of potatoes. Mr. Powers felt that he was well repaid the same season for following this method and that his potato crop the next year would also be considerably better on the lots where the hay was turned under.

MAINTENANCE OF SOIL FERTILITY.

It has been frequently predicted by many persons who have studied the situation that some day the clover crop in Aroostook County will be less successful than it now is. If such a time comes potato growers will very soon begin to suffer for want of more live stock in their system of farming. Although the use of an amount of potash in the fertilizer applied to an acre of potatoes which is twice that actually contained in 100 barrels of the crop probably is of great benefit to the ensuing clover crop, it is impossible to determine how long that supply of potash unaided will insure a good stand of clover. In several different places in the United States it has happened that under such a system of farming without live stock the clover crop in the course of time began to fail and in a few years after the clover crop failed everything else followed it. There is such a section in the southern part of the State of New York where clover, potatoes, and small grains were grown successfully until some twenty years ago. At that time for want of live stock as a source of manure the clover began to fail, and for the last fifteen years there has been no successful clover raising in that section and very few profitable crops of grain or potatoes. Farmers in that section, to be sure, were not using fertilizers to any such extent as are the Aroostook County potato growers, but it does not seem safe to prophesy that even with large amounts of commercial fertilizer the clover crop of Aroostook County can be made a success for an indefinite number of years to come. The extension of the dairy industry, which has such a wide development in other parts of Maine, has been predicted for this county. Dairying may come in to some extent and supply the needs for farm manures, but there are frequent and emphatic objections raised when such a statement is made. Some of the most successful potato growers say that they and their farm laborers are both unaccustomed to the care and handling of dairy cattle and that at certain seasons of the year the time required to care for dairy stock would seriously interfere with the work of potato growing. This objection is very reasonable on farms where the potato business is developed on a large scale, where the acreage grown every year is high, perhaps 50 to 100 acres, and where the owners are not familiar with the methods used in handling cattle.

Pasture land as a rule is of such limited extent as to make sheep raising impracticable. Most potato growers have only a small proportion of the pasture necessary for the number of sheep for which they would have hay. The potato growers of Weld County, Colo., overcome this difficulty by buying range sheep and feeding them for the winter in a small corral. In that way the alfalfa hay grown there in connection with the potato crop and holding the same relative position as clover hay in Aroostook County, Me., is not only consumed on the farm at a profit, but gives sufficient manure to be of great advantage to the farm. There are several farmers in the northern part of Aroostook County, however, whose systems of farming seem to offer another solution of this question. These men are keeping a few brood mares of Percheron blood and find them especially profitable. Heavy draft horses, those weighing 1,400 or 1,500 pounds, are used very extensively in the potato fields, and a good pair is often worth $700 or $800. A great many such horses are brought into the county every year and sold at good prices. The men who are raising these animals on a small scale find them the most profitable means of marketing their hay and grain crops, and as the supply of heavy farm horses is scant as a general thing in all the Eastern States the raising of draft horses promises to be one of the most profitable adjuncts to potato growing in Aroostook County. Raising horses of this type should not be confused with the raising of light-weight horses so often practiced by eastern farmers in trying to raise trotting horses. The ordinary farmer who attempts to raise a trotter is more likely to fail in that and then have a worthless animal so far as good thorough farm work is concerned.

APPLICATION OF BARNYARD MANURE.

Some potato growers say they do not wish to put stable manure on the land for their potato crop. There are two ways of obviating this objection. In every section of the potato-growing States there are numerous instances of the application of manure to the potato crop without injury to the quality of the crop. Generally, however, some precaution is taken in applying the manure. It is usually put on the land during the previous summer if the land is to be fall-plowed, or at least applied in the fall or early winter to land which is to be plowed in the spring for potatoes. If bad results to the potato crop are to be feared from this procedure still further precautions may be taken by applying the manure as a top-dressing on new seeding after the grain is cut. The loose, strawy, rather dry horse manure, such as would be produced on a farm where draft horses are raised, would not ordinarily work well as a top-dressing. It would not decay sufficiently fast nor could it be distributed finely enough, but where lumber is so near at hand and relatively cheap, as in Aroostook County, the farmer will find no difficulty in building some sort of manure shed or small covered barnyard, such as is used in many places in New York and some of the Central States. Under a roof even strawy horse manure when trampled by the stock and allowed to settle and rot to some extent could then be spread successfully as a top-dressing. It would further retain much of its value as a source of nitrogen if treated at frequent intervals with light applications of gypsum, or land plaster.

PROTECTION FROM SCAB.

In the opinion of some of the best potato growers in Aroostook County the trouble which threatens them most seriously to-day is the injury of their crop by scab. Up to the present time very little thought has been given to the treatment of seed potatoes for scab, though great care has been exercised to avoid any treatment of the potato lands tending to encourage the growth of scab, such, for instance, as the application of wood ashes or barnyard manure. The treatment of the seed potatoes with formaldehyde, either in solution or as a gas, is likely to prove of great benefit to the quality of the potato crop in Aroostook County.

ROTATION WITH CLOVER FOR SEED.

A further aid in the improvement of this system of farming is suggested by the experience of the farmers in the potato-growing sections of northern Michigan and by an occasional farmer in Aroostook County. In some parts of Michigan a large part of the clover crop is harvested for seed, in some cases the chaff being fed to sheep or other stock and in others spread on the land. In Aroostook County there have been some excellent yields of clover seed and a handsome profit realized from the crop. Mr. J. W. Dudley has grown on his farm in that county a field of clover of 2½ acres which yielded 5 bushels per acre. The crop was cut August 25, and with clover seed selling at 16 cents a pound was worth $48 per acre. This crop is less expensive to harvest than hay and always involves less risk in curing. Besides these advantages, when the clover crop is harvested for seed, although the seed is sold at a better price than could be realized from hay, all the rest of the crop is returned to the land either as manure or in the form of chaff. With the scarcity of clover seed which has prevailed in recent years and the accompanying high prices, this crop is decidedly one of the most profitable adjuncts to the potato-growing business, especially in those sections where, owing to the latitude, corn is an unsatisfactory crop or where for one reason or another sufficient live stock are not kept to utilize all the feed grown on the place.

SEED SELECTION.

The majority of farmers, even those who make a specialty of potato growing, acknowledge that they use for seed the tubers that are too small to sell, and some even tell boastfully how they have followed that plan for many years and are still raising the same variety. It is at the same time noticeable that a farmer does not often exhibit a variety of potato which he has grown consecutively for many years from seed produced on his own farm. Why should a variety of potatoes "run out" and be discarded after a period of years any more than a variety of corn or apples? The common practice of planting cull tubers very probably explains in part the deterioration of a variety in the Northern States, where the potato plant is in a favorable environment so far as natural conditions go. In contrast to the common practice, an occasional farmer is to be found who uses some care in the choice of seed stock. Some take all of the crop from that portion of the field which has the best stand and gives the best yield, both in quantity and quality. Others pick medium-sized tubers of the desired shape and general appearance from the bins after the crop is in storage. These men usually maintain the yield and quality of their potatoes somewhat above that of their neighbors.

SELECTION BY HILLS.

An occasional potato grower is heard of who gets ahead rather more rapidly by following more thorough methods. One man in Michigan started several years ago by saving a large number of separate hills of potatoes. Each hill was from one seed piece, and only such hills as contained six or more smooth tubers of merchantable size and no cull tubers were saved. Of the potatoes grown in the field the first year, only 16 hills out of every 100 were of the standard required. All the tubers from those hills were planted, and soon enough seed was available for the entire crop, the selection in subsequent years being made from the most thrifty-appearing portion of the field. After the plan had been followed for five years 70 hills out of 100 were found which met the requirements, i. e., the percentage of good hills had been increased from 16 to 70 in five years of selection. The yields on this farm were about double those on the ordinary farm in the same locality, and all the increased yield could not be attributed to the better culture of the crop. The yielding power of the good hills of potatoes in this case was not necessarily increased at all, but the progeny of vigorous plants furnished more and more of the seed for the crop. The writer has had the opportunity to select some hills of Rural New Yorker potatoes for two years. The first year 8 per cent of the hills were saved, and of the crop grown from that 8 per cent the second year there were found to be 20 per cent which met the requirements. (See fig. 11.)

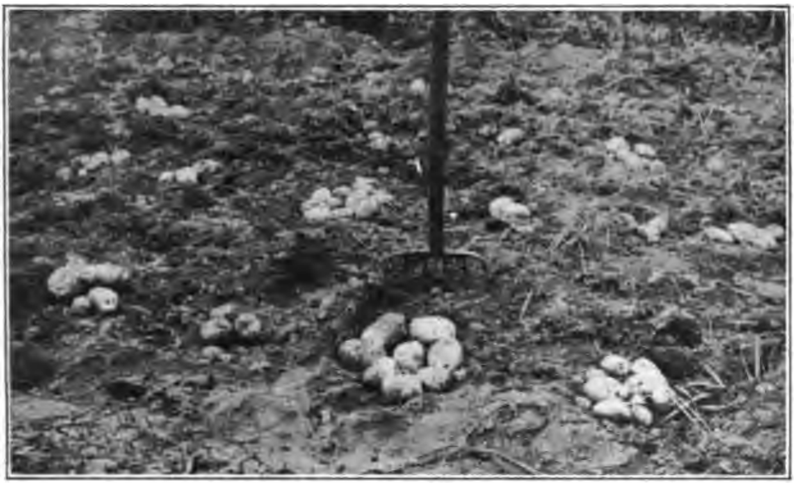

FIG. 11.—Individual hills of potatoes as they grew in the field, with good and poor hills close together.

Some of the State agricultural experiment stations have carried on the hill selection of potatoes for two or three consecutive years, far enough at least to show definitely that the increased yield of a variety comes most rapidly and unfailingly from the hill method already suggested, provided a hill grows from one piece of seed as the unit of selection. Even though no change is brought about in the character of the seed the percentage of unproductive seed is decreased by this means, and the standard of the whole approaches that of the few best hills in the beginning. (See fig. 11.)

No matter how good a tuber is it may come from a distinctly poor hill where it was the only good potato out of many, the rest being all of unsalable size. The tendency for a tuber to reproduce not the characteristics of itself alone, but those of the whole hill of which it was a part, was indicated by the experiments referred to. For the reason, no doubt, that many of the small potatoes come from heavily yielding hills the seed derived by planting culls continuously runs out slowly. In short, even a small potato from a good hill of which it was the only small tuber is preferable to a large tuber from a poor hill where it grew with many small ones. As medium-sized potatoes are preferable to excessively large ones not only for seed but for general table use (aside from cooking in some few special ways), the grower should select as a standard the hills which contain a large number of medium-sized tubers, say from eight to ten, with little or no waste. A very large number is probably not advisable, for the tendency to set so many tubers would be a disadvantage should that seed be planted under unfavorable conditions of soil or climate.

As the northern potato-growing States furnish not only the seed for their own crop but that for the early crop throughout the South, the productiveness of the standard varieties of potatoes must be maintained in the North. The improvement in yield of an old variety, well tried out, is vastly more important than the originating and promoting of new varieties, and this latter task should be left to the specialist.

To the potato grower who would improve his potatoes in yield and quality a few general directions can be given, as follows:

Dig a few hundred hills by hand out of the most thrifty-appearing portion of the field and let each hill lie by itself when dug. From them select such hills as comply with the standard suggested, no matter how small a percentage of such hills is obtained. By planting these selected hills in a few separate rows and digging them the following season in the same way the first selection was made, the work of selection may be decreased. The selected hills should be planted in a seed plot each year and all the rest of the product of the plot of the previous year should be used in planting the main crop. It is inadvisable to have the seed bed on particularly rich soil, but rather under just such conditions of care and soil as the main crop. When one becomes sufficiently familiar with the appearance of separate hills and the difference in character between them, it is possible for him to select the desirable hills by following behind the digger, especially when the hills are not planted too close together in the row. With this way of making the selection, a small plot in which the selection is made by hand digging should still be kept.

CONCLUSIONS.

The recommendations to be made in methods of handling the potato crop, based on observing potato growing in various sections of the North as thus far described, are briefly as follows:

Soils adapted to potato growing.—The growing of potatoes is not by any means necessarily confined to a limited class of soils. In general, the crop is more successfully handled on soils which are naturally well drained, but sometimes equally successful results are obtained on rather heavy or moist soils which have been tile drained.

Importance of rotation of crops.—The rotation of crops in which potatoes are grown appears to be one of the most important factors for the continued success of the potato grower. The rotation should in general be the shortest which is found practicable in meeting the other demands of the farm and should be such as to give a good stand of some leguminous crop the season previous to the potato crop. Usually in northern sections the best adapted and most useful crop is clover, which should be cut for hay only one year before the land is plowed and planted to potatoes. In the North the length of time required to establish clover permits the introduction of a spring grain crop without loss of time.

Use of commercial fertilizers.—Well-chosen commercial fertilizers have been shown to be profitable when not applied to excess. The fertilizer should be selected for its formula and not on account of the statements of a manufacturer who calls it a "potato fertilizer." It is not advisable to buy a large proportion of nitrates in the form of commercial fertilizers, since a careful potato grower can furnish them more cheaply by means of plowing under the sod and stubble of leguminous crops.

Application of barnyard manure.—The man who has a supply of barnyard manure on his farm every year is the one who will find it most easy to keep up his yield of potatoes from year to year. Barnyard manure is not as a rule suitable for direct application to the potato crop, because when so applied it favors the development of scab, but in a short rotation it may be used far enough in advance of the potato crop to avoid this difficulty and in such a way as to keep up the supply of humus in the soil. Thus potato growing is possible even after the crop has been grown at intervals of three or four years for a long period of time.

Necessity for thorough cultivation of the crop.—Thorough tillage seems even more important for the potato crop than for the other ordinary field crops, since the tubers demand a soil which is not compact, in which they may grow to good size and be of regular shape. This is accomplished by deep plowing and otherwise thorough fitting of the land before planting and by continued working of the crop after planting. The crop should not, however, be cultivated deep, especially close to the rows, after the vines have attained any considerable size. In the drier soils and climatic regions the more level the cultivation the better for the crop. The potato row should never be hilled up, if it is possible to avoid it, in a loose, well-drained soil where the rainfall is not excessive. The seed should be planted deep in the first place, so that the tubers will grow beneath the surface without hilling. In sections where the soil is more moist and the rainfall during the summer likely to be overabundant, planting more shallow and hilling up somewhat will place the seed in a warmer soil for early growth and do much toward keeping the crop suitably drained later in the season.

Spraying to prevent blight.—In the humid climate of the region near the Great Lakes and eastward to the Atlantic coast, spraying with Bordeaux mixture as a preventive of serious damage by blight is far more profitable and effective than any subterfuge, such as late planting, which may be employed.

Machinery desirable.—The thoroughgoing use of machinery in potato growing is one of the most important factors in making a crop profitable. Even when a farmer grows such a small acreage as to make it not worth while to own a planter or digger he can at least reduce the hand labor on his crop by avoiding any hoeing unless it be to cut out a few large weeds in the middle of the season. Hand hoeing can be practically eliminated on any potato field by the frequent and thorough use of a common cultivator of any kind, together with either a horse hoe for hilling the crop or a weeder for the early work in level cultivation. Both the horse hoe and ordinary weeder are inexpensive implements and the work of the latter may be accomplished with a smoothing harrow. In communities where each farmer grows only a small acreage of potatoes still further gain is made by using one planter or one digger on several farms, either as the result of joint ownership or renting of the machine.

Marketing the crop.—The successful marketing of potatoes depends very little on the immediate proximity of a center of population large enough to consume them. Unless some local freight rate is particularly exorbitant, shipment for 200 or 300 miles is no obstacle in growing potatoes. The principal requisite in shipping the crop is to have sufficient quantities to ship the potatoes in carload lots of 500 to 600 bushels. With good management a potato crop should be profitable at a selling price of 35 cents a bushel.

Maintaining a supply of humus in the soil.—Of the three sources of fertility utilized in growing a potato crop two of them together are often used with good success, but the use of all three—a rotation which provides some leguminous crop directly preceding the potatoes, live stock which furnish barnyard manure, and some form of commercial fertilizer containing potash and phosphoric acid—brings the most successful results in economical potato production, especially when continued throughout a long period of years. On this account potato growing is often most successful on live-stock farms in the Northern States, and on such farms where most of the other crops produced are used for feeding some kind of stock the potato fits into the rotation remarkably well. On a dairy farm, for instance, where a short rotation of silage corn, small grain for hay or grain, and clover hay is grown, a potato crop is most easily fitted into the rotation, being planted on the clover sod and followed by a crop of corn for silage, the manure from the live stock being used on the corn crop and as a top-dressing on the hay crop after the grain is harvested. This is not only most advantageous for the potato crop, but this procedure gives the farmer whose income is otherwise entirely from his dairy cattle and other live stock a cash crop to sell outright and one that is safe and far more profitable than a crop of wheat, for instance, could possibly be. Potato growing in the States where it now is conspicuous seems likely to increase along with the increase of dairying or other forms of live-stock farming and not to the exclusion of those types. On the other hand, intensive live-stock farming is not likely to crowd out potato growing, but rather to increase the total production if not the acreage of the potato crop.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 366.

Experiment Station Work,

LII.

[Corrected to April 20, 1910.]

Compiled from the Publications of the Agricultural Experiment Stations.

TREATMENT OF MUCK SOILS.
MANURES FOR TIMOTHY HAY.
CORN BREEDING.
YELLOW BERRY IN WHEAT.
WEED SEEDS IN FEEDING STUFFS.
HOOK-WORM DISEASE OF CATTLE.
EFFECT OF MACHINE MILKING ON COWS.
MILK SUPPLY OF CITIES.
THE CROW.
LABOR, WAGES, AND COST OF BOARD IN MINNESOTA.

MAY, 1909.

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A. C. TRUE, Director.

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1910.

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[b] Special agent in charge.

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EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

CONTENTS OF NO. LII.

Page.
Treatment of muck soils 5
Manures for timothy hay 6
Ten generations of corn breeding 10
Yellow berry in hard winter wheats 13
Weed seeds in feeding stuffs 16
Hook-worm disease of cattle 17
Effect of machine milking on individual cows 19
Milk supply of cities 20
The crow as a menace to poultry raising 28
Hours of labor, wages, and cost of board on Minnesota farms 20

EXPERIMENT STATION WORK.[a]

TREATMENT OF MUCK SOILS.[b]

Muck soils are widely distributed, in small or large areas, in the United States. When properly drained and handled they are in many cases extremely productive. The amount of muck land reclaimed by drainage and brought under cultivation is rapidly increasing, and it is becoming a matter of considerable importance to know the best methods of utilizing such lands. Extensive areas of muck soils are found in Florida, and in a recent bulletin of the Florida Station, A. W. Blair summarizes the results of his study of these soils and makes suggestions regarding their treatment which are of general interest. He states that "muck soils are formed by the decay, in low wet places, of grasses, weeds, twigs, leaves, and even trees. Being so largely formed from vegetable matter, they are much richer in nitrogen than ordinary soils. They usually also contain small amounts of phosphorus and potassium."

It is recognized, of course, that proper drainage is a necessary prerequisite to the use of muck soils, for "if muck soils are to be cultivated it is obvious that they must first be drained. This is necessary in order that they may become the home of the various kinds of micro-organisms that play an important part in the making of a fertile soil. These micro-organisms need moisture, but they can not develop in mud or standing water."

The method of cultivation requires particular attention.

> Cultivation should be deep, especially at first, in order that the air may thoroughly penetrate the soil. Muck soils often contain substances that are injurious and even poisonous to plants. When these poisonous substances are exposed to the air they are probably oxidized to a considerable extent and thus destroyed. A free circulation of the air also improves the conditions for the development of the useful micro-organisms.

Muck soils are generally acid or sour, and this acidity must be corrected before they will be productive.

> Suitable materials for this purpose are finely ground limestone, air-slaked lime, wood ashes, and marl. Finely ground limestone (the native rock) is to be

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Florida Sta. Bul. 93; Press Bul. 109.

preferred to the forms commonly used, since it is effective, is more easily handled, and harm is not likely to result from the use of amounts in excess of what is needed to neutralize the acids.

It will be necessary in most places to use larger quantities [of neutralizing material] on muck soils than on upland soils. If limestone is used, 2 to 6 tons per acre should be applied. If lime is taken, a ton and a half or two tons may be used. The material should be thoroughly worked into the soil one or two months before the crop is planted. This will give time for the lime to neutralize the acid.

The importance of destroying the acids can be better appreciated when we remember that the micro-organisms that convert organic nitrogen into a form that can be used by plants can not develop in a highly acid soil. The limestone and lime also furnish a suitable base with which the nitric acid that is formed may unite, thus producing calcium nitrate which can be taken up by plants.

If muck is to be used [for fertilizing purposes] on upland soils, it is also necessary for the acids to be destroyed. This can be done either by composting it with one of the materials already mentioned, or by applying the latter when the muck is applied, or afterwards, and thoroughly mixing both with the soil by cultivation. Muck may be improved by simply drying and thoroughly airing it. This is especially true of mucks that contain iron compounds. We can not expect a satisfactory yield of such crops as celery and lettuce on muck land until the acids have been largely destroyed.

It occasionally happens that a muck deposit is underlaid with marl, or is in close proximity to a limestone formation. In such cases it is not so likely to be acid, and might not require the treatment with lime.

Muck soils being especially rich in nitrogen should, one would think, require but little, if any, of the nitrogenous fertilizers. Experience, however, has shown that in many cases they do require added nitrogen. This is because they are so strongly impregnated with acids that the bacteria which would otherwise convert the inert nitrogen of the organic matter into soluble nitrates can not live. When this unfavorable condition has been corrected, less nitrogen in the form of commercial fertilizer will be required. If a quick-growing vegetable crop is being produced, nitrate of soda may be used to good advantage, as may also stable manure, since it introduces beneficial bacteria; but sulphate of ammonia and organic forms of nitrogen (such as cotton-seed meal and castor pomace) should not be used; the former because it will aggravate the acid condition and the latter because there is already enough organic nitrogen present. Phosphoric acid and potash may be used liberally if desired. For phosphoric acid, ground bone is an excellent material; while a ton or two of finely ground phosphate rock (floats) would also be helpful; not so much, however, for immediate results as for future crops, since the acids in the muck will very gradually convert the insoluble phosphoric acid into the available form. For potash, any of the potash salts will suit. Kainit has been used on the muck soils of Illinois with good results. Hard-wood ashes are an excellent source of potash, if they can be produced on the place or bought at a reasonable price.

MANURES FOR TIMOTHY HAY.[a]

The value of the hay crop of this country is exceeded only by that of corn and cotton, yet it is evident to those who have inquired into the matter that neither in quantity nor in quality is this crop what it might easily and profitably be made. Grass lands do not as a rule receive the care and treatment their importance warrants, and the improvement of hay-producing plants has been given less attention than that of many other farm crops. This Department and several of the experiment stations have, however, realized the importance of the hay crop and are making efforts to bring about improvements in its production.

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[a] Compiled from New York Cornell Sta. Bul. 261.

The New York State and the New Jersey experiment stations have shown that nitrogen is the predominant constituent in a fertilizer for timothy and grasses in general, and have indicated how nitrate of soda may be profitably used for increasing the yield of such plants.[a] The Maine Experiment Station has shown how to prepare home mixtures of fertilizers suited to grass lands.[b] The Rhode Island Experiment Station has very carefully worked out the most suitable methods of top-dressing grass lands in order to maintain a good yield without the use of manure.[c] The West Virginia Station, on the other hand, has shown how grass lands may be improved by the continuous use of manure alone.[d] The Oklahoma Station has done much to improve the hardiness and yield of Bermuda grass as a hay plant and to extend its use in regions of scanty or uncertain rainfall.[e]

Timothy may be taken as the type of hay grasses, and results obtained with it may be considered as in large measure representative of and applicable to such grasses in general. For several years the New York Cornell Experiment Station has been investigating the best means of improving the quality and increasing the yield of timothy hay. A recent report by J. A. Bizzell and J. O. Morgan sums up the results of these investigations, which included more particularly experiments with stable manure (10 to 20 tons per acre) and various combinations of nitrate of soda (160, 320, and 640 pounds per acre), superphosphate (320 and 640 pounds per acre), and muriate of potash (80 pounds per acre) applied in a six-year rotation of corn, oats, wheat, and timothy (three years) on plats of a tenacious clay loam (Dunkirk clay loam). The soil on which these experiments were made is difficult to work except when moisture conditions are most favorable, but is considered a type of soil well adapted to timothy.

The plan was to seed to wheat and timothy in the fall of 1903, so the first application of fertilizers and stable manure that the plats received, was made September 16, 1903. Early fall rains prevented the seeding of wheat, as planned, and in the spring of 1904, on April 15, oats were sown at the rate of

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[a] U. S. Dept. Agr., Farmers' Bul. 210, p. 6.

[b] U. S. Dept. Agr., Farmers' Bul. 222, p. 8.

[c] U. S. Dept. Agr., Farmers' Bul. 227, p. 5.

[d] U. S. Dept. Agr., Farmers' Bul. 276, p. 18.

[e] U. S. Dept. Agr., Farmers' Bul. 320, p. 12.

9 pecks per acre together with timothy at the rate of 15 pounds per acre, without the application of any further fertilizers. The second application of fertilizers was made April 5, 1905; the third application, April 17, 1906; and the fourth, May 1, 1907. Stable manure was not added every year as were the fertilizers, the second application being made October 2, 1906.

One-half of each plat was treated with slaked lime at the rate of 1,000 pounds per acre.

In attempting to draw practical suggestions from the results of these experiments attention is especially called to the fact that—

> It is difficult to make definite recommendations in regard to the use of fertilizers for grass lands. It is definitely known that chemical fertilizers very often, we may say usually, exert a marked influence on crops, but it is almost impossible to say just what fertilizers or how much of them should be used in a given case with the assurance that the results will be favorable. Every farmer must experiment with his own land, using the experience of other farmers and investigators as suggestions only.

The experiments, however, make it clear that "of the fertilizing elements usually applied as plant food, nitrogen seems to be the most potent factor in increasing the yield of timothy and related grasses. Unlike the clovers and other leguminous plants, timothy is incapable of acquiring any of its nitrogen from the air, but must depend on that supplied to the soil. The best evidence shows that it requires for its full development a liberal supply of nitrogen throughout the growing period," a fact which has also been clearly demonstrated by the New Jersey, New York, and Rhode Island experiment stations. While nitrogen thus appears to be the dominant fertilizing constituent, it attains its greatest efficiency only when judiciously combined with potash and phosphoric acid.

In the Cornell experiments "the best financial returns were obtained when farm manure was applied at the rate of 20 tons per acre." In the experiments at the West Virginia Station, to which reference has already been made, there was not only a net profit of $36 per acre from applications of 10 to 15 tons per acre of manure for six years, but the soil was in much better condition at the end than at the beginning of the experiment.

> The lasting effects or the value of farm manure to later crops should always be considered when comparing it with the value of commercial fertilizers. On the Dunkirk clay loam of New York State the best financial returns may be expected from the use of farm manure when the latter can be purchased for 50 cents a load. This estimate does not include the effect on subsequent crops, to which a value should be assigned.
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> For the New York farmer who wishes to raise a large proportion of hay on this type of soil an eight-year rotation may be suggested—wheat one year, hay five years, corn one year, and oats one year. The farm manure should be incorporated with the soil previous to seeding with timothy and wheat in the fall. In the following spring a mixture of red and alsike clover should be seeded. Annual applications of farm manure should then be made for the grass

crops, the applications being given as top-dressings in the fall and harrowed in the following spring. For the corn crop a similar application may be made. No fertilizer of any kind need be applied for the oats. It might be advisable in some cases to make top-dressings of manure once in two years, in which case larger applications should be made.

When farm manure can be procured in sufficient quantity the use of commercial fertilizers is not necessary. But the farmer often finds it advantageous to reserve a large part of the farm manure for other crops, in which case commercial fertilizers may be substituted wholly or in part if used judiciously. When the supply of farm manure is limited it would be advisable to use smaller applications in the fall than stated above, supplementing this in the early spring by small applications of the commercial fertilizers.

Of the commercial fertilizers, the most satisfactory returns were obtained on Dunkirk clay loam by the use of a complete fertilizer consisting of 320 pounds of nitrate of soda, 320 pounds of acid phosphate, and 80 pounds of muriate of potash per acre.

It is believed, however, that the use of a mixture of 200 pounds of nitrate of soda, 100 pounds of superphosphate, and 50 pounds of muriate of potash per acre would be more economical, but in any case "it would be best for the farmer to determine by actual field tests the quantity most desirable for his land."

As the mixed fertilizers found on the market usually do not contain the elements in the proportion suggested by the above formula, it would be best for the farmer to buy the separate ingredients and mix them himself. The ingredients called for are usually sold under guaranty by the fertilizer companies and vary little from the following composition: Nitrate of soda, 15 to 16 per cent nitrogen; acid phosphate, 12 to 14 per cent available phosphoric acid; muriate of potash, 50 per cent potash.

There are certain advantages in home mixing to which attention is called, but it is pointed out that if home mixing is undertaken it is quite important that it should be carefully done in order that thorough and even mixtures may be obtained.

Commercial fertilizers are well adapted to top-dressing grass lands, since they can be easily applied by hand and since they contain the plant-food elements in an easily soluble form, and are therefore immediately available to the growing crop. Because of their ready availability there is danger of loss by leaching. In view of this fact they should be applied in the early spring, just as the grass is beginning to grow.

In the experiments at the Rhode Island Station referred to above it was found that a mixture of 400 to 500 pounds per acre of superphosphate and 300 to 350 pounds of muriate of potash and nitrate of soda applied as an annual top-dressing from April 15 to 25 would maintain a good yield of timothy without the use of stable manure, which is subject to the objection that the coarser undecomposed material of the manure remaining upon the meadow is likely to be raked up with the hay, and that the manure sometimes has the effect of reducing the quality of the grass by causing a rank growth or by the introduction of weeds.

In the Cornell experiments the use of lime did not result in an increased yield of hay. It has, however, been demonstrated by the Rhode Island Station that timothy does not thrive on acid or sour soils and that the most effective practical means of correcting the acidity is by the application of lime or wood ashes.

TEN GENERATIONS OF CORN BREEDING.[a]

As the work in corn breeding is carried on from year to year and the accumulation of data increases, knowledge regarding the extent to which certain characters may be influenced becomes more definite. Furthermore, other lines of work suggest themselves. The Illinois Station has recently summarized the results of several lines of its corn-breeding work in progress for a series of years, which indicate clearly how pliable the corn plant may become in the hands of the plant breeder. The work with reference to changing the composition of the grain, more particularly the protein and oil content, and thereby adapting it to certain special purposes, has been described in previous bulletins of this series and the earlier results secured were noted in that connection.[b] This work of selection and breeding is based upon the results of analyses of different ears from a single variety, together with the results of analyses of different parts of single ears, which established the fact that the ear of corn is approximately uniform in the chemical composition of its kernels and that there is a wide variation in the chemical composition of different ears of the same variety. The breeding has now been carried through ten generations, and its effect is indicated by the data compiled from the general averages of each generation as shown in the following table:

Ten generations of breeding corn for increase and decrease of protein and oil.

Year.	High protein.		Low protein.		Difference.	High oil.		Low oil.		Difference.
	Seed.	Crop.	Seed.	Crop.		Seed.	Crop.	Seed.	Crop.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1896......	....	10.92	....	10.92	....	....	4.70	....	4.70	....
1897......	12.54	11.10	8.96	10.55	0.55	5.39	4.73	4.08	4.06	0.67
1898......	12.49	11.05	9.06	10.55	.50	5.20	5.15	3.65	3.99	1.16
1899......	13.06	11.46	8.45	9.86	1.60	6.15	5.64	3.47	3.82	1.82
1900......	13.74	12.32	8.08	9.34	2.98	6.30	6.12	3.33	3.57	2.55
1901......	14.78	14.12	7.58	10.04	4.08	6.77	6.09	2.98	3.43	2.66
1902......	15.39	12.34	8.15	8.22	4.12	6.95	6.41	3.00	3.02	3.39
1903......	14.80	13.04	6.98	8.62	4.42	6.73	6.50	2.62	2.97	3.53
1904......	15.39	15.03	7.00	9.27	5.76	7.16	6.97	2.80	2.89	4.08
1905......	16.77	14.72	7.09	8.57	6.15	7.88	7.29	2.67	2.58	4.71
1906......	16.80	14.26	7.21	8.64	5.62	7.86	7.37	2.20	2.66	4.71

With reference to protein these results show that, starting with a single variety, it has been possible in ten generations of this work

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[a] Compiled from Illinois Sta. Buls. 128, 132.

[b] U. S. Dept. Agr., Farmers' Buls. 193, p. 20; 210, p. 11.

to increase the protein content from 10.92 per cent to 14.26 per cent, a gain of 3.34 per cent, while by breeding in the opposite direction it has been possible to reduce the protein content from 10.92 to 8.64 per cent, or a reduction of 2.28 per cent, making a total difference between the two strains of 5.62 per cent. It is further shown that the high-oil corn has increased from 4.70 per cent to 7.37 per cent of oil, while a low-oil corn has decreased from 4.70 to 2.66 per cent, the difference between the two strains in 1906 being 4.71 per cent. Individual ears ranged in protein content from 6.13 per cent in the low-protein strain to 17.79 per cent in the high-protein strain, and in oil content from 1.60 per cent in the low-oil strain to 8.59 per cent
in the high-oil strain. In other parts of the plant the proportion of
rotein is never as high as in the grain. The leaves averaged some-
hat higher in protein than the stalks, but this condition was not
onstant in every year. No regular difference between the upper
nd lower portions of the stalk with reference to protein was estab-
shed. The crude fat in other parts of the plant scarcely ever
proached the oil content of the kernel, and was generally greater
the lower stalk and leaves than in the upper stalk.

High-protein and low-protein seed were planted together on one
t and high-oil and low-oil seed on another. These plats were con-
ued for three years, and the results secured did not indicate that
soil influences the protein or the oil content. Continued selection
apparently induced a certain correlation between protein and oil
tent, and has resulted in characteristic types of kernel and per-
ible modifications in the type of ear. Selections for high protein
nsidered as evidently accompanied by a reduction in yield. It
so stated that climatic conditions exert, in certain years, a marked
t upon the composition of the corn crop as regards its protein,
nd starch content.

e phosphorus content was found always somewhat higher in
over and the grain from the high-protein plat. On the high-oil
ow-oil plats the phosphorus was regularly higher only in the
il grain. In general, the grain was decidedly the part richest
osphorus. The stover carried a much larger proportion of
ium than the grain, but the stalks and leaves did not vary much
respect. In general, however, aside from the correlation de-
d between protein and oil in the kernel, the changes in com-
n due to breeding have not been very marked.

her line of breeding of more recent origin has also given
ing results. In 1902 two sets of ears of Leaming corn, the
resenting ears growing high on the stalk and the other those
ow down on the plant, were selected. The following year
was planted in a breeding plat and the selection for high and

low ears continued each year. The results of this work are summarized in the following table:

General averages of crops produced in corn breeding for high ears and for low ears.

Year.	Height of ear.		Height of plant.		Number of internodes below ear.		Total number internodes of stalk.	
	High-ear plat.	Low-ear plat.	High-ear plat.	Low-ear plat.	High-ear plat.	Low-ear plat.	High-ear plat.	Low-ear plat.
	Inches.	*Inches.*	*Inches.*	*Inches.*				
1903	56.4	42.8	118.9	102.5	8.5	7.2	15.4	12.9
1904	50.3	38.3	106.2	97.4	7.5	6.2	14.5	12.0
1905	63.3	41.6	128.4	106.5	8.2	6.5	15.4	12.6
1906	56.6	25.5	116.8	86.0	9.0	5.9	15.1	11.0
1907	72.4	33.2	130.4	99.7	9.2	5.8	16.3	12.0
1908	57.3	23.1	114.0	79.3	8.2	4.7	15.5	11.5

The results show that two strains of corn have been produced, one of which bears the ears about 3 feet higher on the stalk than the other. The high-ear strain has longer stalks, longer internodes, a greater total number of internodes, and a greater number of internodes below the ear than the low-ear strain.

Perhaps the most significant of all, as throwing light upon broader problems of heredity, is the fact brought out by these results that the corn has not only responded to the selection, but there has been a gradual progressive shifting of the types so that even in the fourth generation the average height of ears in the one strain is more than twice that in the other.

The smaller type of plant, or the low-ear strain, has a shorter growing period than the high-ear strain. In yield of grain no great difference is indicated, but the high-ear strain produces the greater yield of fodder.

The experiments to influence the declination of ears was begun in 1903, and the selections were made according to the angle of declination at harvest time from "Illinois High Oil" corn, a strain under selection for seven generations for increase in oil content. The results of this experiment are brought together in the following table:

Average degrees of declination of ears from the perpendicular in breeding for erect ears and for declining ears.

Year.	Average of seed.		Difference between strains.	Average of crop.		Difference between strains.
	Erect-ear strain.	Declining-ear strain.		Erect-ear strain.	Declining-ear strain.	
	°	°	°	°	°	°
1904	20.0	180.0	160.0	42.0	45.0	3.0
1905	16.7	180.0	163.3	62.2	117.1	54.9
1906	15.0	180.0	165.0	49.5	76.2	26.7
1907	12.8	180.0	167.2	42.8	81.6	38.8
1908	7.2	176.0	168.8	46.0	88.5	42.5

The results show that the declination of the ear is a character that can be influenced by breeding. The length of shank is apparently the principal factor in determining the declination. The declining ear is the better protected from rain, and is harvested with greater facility.

YELLOW BERRY IN HARD WINTER WHEATS.[a]

By the term "yellow berry" is meant the appearance of grains of a light yellow color, opaque, soft, and starchy in hard winter wheats which normally produce a hard, flinty, translucent grain of medium size and of a clear, dark, reddish-amber color. Sometimes only part of a kernel will show the yellow berry characteristics, while the remainder has retained the normal translucency and hardness. The region comprising the central and northern part of Kansas and the southern part of Nebraska produces a milling wheat of the best grade, because of a very high content of gluten of excellent quality and texture. As the presence of yellow berry lowers the grade of wheat and reduces its value for milling purposes, the reduction, and preferably the total elimination, of yellow berry is of vital importance to the farmers of the hard winter wheat section and to the millers who grind this grain. The Nebraska and Kansas Experiment stations are at work on the problem, and the reports of progress made in their investigations, published in recent bulletins, form the basis of this article. There are different views regarding the causes of yellow berry. Some consider it the result of degeneration in the variety, others believe it to be due to climatic and soil conditions, or egard it as a consequence of sowing the same seed year after year, vhile still others attribute it to the condition of the crop at the time f harvesting. The object of the experiment station work is to deermine definitely the causes of this trouble, and to find ways and eans of reducing or preventing it.

The results of this work, with reference to the physical characters f the yellow berries, call attention to the fact that the difference color between the flinty and the soft and opaque grains is due to difference in the structure and contents of the cells of the endoerm; that in weight, as well as in specific gravity, the affected ains fall below the normal kernels of the same variety; and that e yellow berries show a reduced protein content. Lyon and Keyser, the Nebraska Station, found that in the yellow and opaque kernels e starch grains in the cell were larger in diameter than in the flinty rnels, although not so large as in the typical starchy wheats.

Compiled from Kansas Sta. Bul. 156; Minnesota Sta. Bul. 90; Nebraska . Bul. 89.

In 21 varieties examined by the Kansas Experiment Station the average weight of the yellow berries per hundred was 2.596 grams, and that of the hard, flinty grains 2.740 grams. The average specific gravity of the yellow berries was 1.304, and of the normal grains 1.336. It is believed that the reduction in specific gravity is probably due to the more numerous and larger air cavities within the kernel, and possibly also to a reduced starch content. Data at hand indicate that the ordinary soft and starchy wheats of the Pacific coast and the Middle and Southern States average somewhat higher in weight per bushel than the hard winter and spring wheats, and that the yellow berry in this respect does not resemble the soft wheats, the weight as well as the specific gravity falling below the flinty kernels of the same variety. Analyses made at the Nebraska Station showed that samples of hard winter wheat contained an average of 2.79 per cent of nitrogen, while corresponding samples of yellow berry contained only 2.38 per cent, thus indicating a reduction in the gluten content and a consequent diminution in the flour-making value in the grain due to yellow berry. Regarding the merits of hard and soft wheats for milling purposes, Professor Snyder, of the Minnesota Station, says:

> It is generally considered that the more amber and glutenous wheats yield a higher percentage of the patent flours and less of the clear and lower grades, while the lighter colored or starchy wheats show a tendency to produce a higher percentage of total flour, but less is recovered as patent graded. * * * These physical characteristics are closely associated with, and dependent upon, chemical composition. * * * When two types of seed, light and dark, were selected from the same lot of wheat, the darker seeds in all samples analyzed were found to be richer in protein.

To determine the relation between the amount of yellow berry produced under the climatic conditions of the particular seasons, 128 varieties of wheat were grown by the Kansas Station during 1906–7. The heads were harvested when considered fully ripe and dried under cover, so that the existence of yellow berry could not be attributed to overripeness or exposure to the weather after cutting, but could only be ascribed to the influence of the weather before harvesting the heads or to inherent hereditary tendencies in the varieties themselves, or to both. The results with regard to the relation of temperature, light, air movements, and precipitation to the growth of the wheat plant, and the possible share of each factor in the production of yellow berry, were found to be extremely complex and intricate of interpretation. The influences of the autumn vegetative conditions were studied both years, and the data for the two seasons show the same diminution in the percentage of yellow berry with the shortening of the fall vegetative period and a corresponding decline in the mean temperature for that period. The first year the wheat was sown on six different dates, from September 28 to October 16, inclusive. A general decrease in the amount of yellow berry was observed as the wheat was planted later. The earliest sown plat contained 53.80 per cent of yellow berry, while the latest sown plat contained only 19.58 per cent, these quantities being the highest and lowest in the series, respectively. The second year, when the wheat was sown on September 26, 27, 28, and 29, there was a correspondingly lower range in the average percentage of yellow berry from the different plantings, the highest being 44.33 per cent for the wheat sown on September 26 and the lowest 32.63 per cent for the wheat sown September 29. Apparently the reduction in the total length of the growing period with the later plantings, the consequent lower mean temperature for the period of fall growth, and the necessarily retarded and diminished development of the plants is in direct correspondence with the subsequent development of yellow berry, in so far as these data are concerned.

A study of the vegetative spring conditions in their relation to the production of yellow berry did not give very definite results. For instance, the mean temperature for two weeks before ripening did not show any definite relationship to the yellow-berry problem, but when the possible influence of this factor was traced back to the appearance of the spike, the total averages for the two years indicated that high temperatures are correlated with a minimum of yellow berry. The amount of rainfall from the sixth day before heading to the fourth day before ripening gave no indication of correlation with this difficulty. The complicated and, in many instances, contradictory results secured in this line of investigation lead the authors to conclude that not only climatological conditions but also hereditary tendencies form an important factor in causing the appearance of yellow berry in the grain.

Among the many cultures examined planted side by side on the same day and ripening on the same date the percentages of yellow berry varied widely. Strains and varieties grown in 1906 were grouped into those wheats producing from 1 to 25 per cent, from 25 to 50 per cent, from 51 to 75 per cent, and from 76 to 100 per cent of yellow berry. The crop of 1907 from these groups showed in general that the averages for each had the same relative position that they occupied in 1906. The minimum range in the varieties lay in those groups of 1907 that came from the minimum groups of 1906. The varieties low in yellow berry had progeny in 1907 which averaged 12.25 per cent higher than the average of the corresponding parental groups for 1906, yet on the other hand the varieties high in yellow berry had progeny which averaged 27.41 per cent lower than the average of the corresponding parental groups for 1906. The hard grains planted in 1906 were much heavier than the soft ones and as a rule the yields from the heavy hard grains were the greater.

In studying the degree of inheritance of yellow berry in pure-bred or pedigree wheats it was observed that in the first progeny group in 1907 a little over one-third produced no yellow berry at all, while the average of all was 3.9 per cent. In the selections of spikes from common commercial varieties, as well as in the selections of hard and soft grains in these varieties, there were no cases whatever where the offspring was free from yellow berry. The averages for the lowest groups in the case of common commercial varieties and in the selected hard and soft grains were 36.95 and 50.40 per cent, respectively. It appears in general from the results that with the percentage increase of yellow berry in the parents a mean percentage of yellow berry in the offspring was observed, and it is considered as very evident that the pedigree-culture method so far as the elimination of the yellow berry is concerned is superior to the other methods tried. In the common commercial variety lots of parents all contained yellow berry, but there were 61 cases in which the percentage ranged from 1 to 25. The progeny of these in 1907 showed a mean percentage of yellow berry of nearly 37, while among the pedigree cultures there were 38 or 36 per cent which fell in the 1 to 25 per cent class of the parents, but which in 1907 had a mean percentage of only 7.9. The minimum or zero class of parents gave rise also to the minimum class of offspring in the case of pedigree wheats.

The results as a whole indicate that while yellow-berry production may be influenced to the extent that it is possible to control the length of the fall vegetative period, and through this the mean temperature, the solution of the problem seems to lie after all in the hands of the plant breeder, as the tendency to produce yellow berry is found to be more marked in some strains than in others and is heritable. It is believed that from a group of pure-strain pedigree wheats producing no yellow berry for two successive years a race may be derived from which the tendency to deterioration may be entirely eliminated.

WEED SEEDS IN FEEDING STUFFS.[a]

In a recent bulletin of the Connecticut State Station, E. H. Jenkins emphasizes the danger of the introduction of weeds by the use of feeds made up in part or in whole of grain screenings and similar materials, which as a rule contain a large amount of weed seeds.[b] "These screenings vary a good deal in quality. Thus an analysis recently made of wheat screenings showed about 33 per cent of flax and shrunken cereal, 15 per cent of foxtails, 8 per cent of bindweeds and pigweeds, 15 per cent of weed seeds of other species, and 21 per cent of dust, broken seed, and sand. Even such a mixture is much better than many others which often contain very little, if any, wheat or flax." Examinations of a large number of feeds in which such materials were used showed that "every pound of each of these mixtures brings to the farm from 5,000 to 86,000 seeds, of which, in some cases, 100, in others more than 22,000, are alive." Among the weeds of which seeds were found in the feeds were false foxtails or bottle grasses, pigweeds or lamb's quarters, knotweed or bindweed, black mustard, charlock, ragweed, Panicums, sorrel, dock, common and Canada thistle, and catchfly.

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[a] Compiled from Connecticut State Sta. Bul. 161.

[b] See also U. S. Dept. Agr., Farmers' Bul. 334, p. 18.

While it may be granted that the ground seed of certain weeds may ave some food value, "it is very doubtful if small whole seeds are roken up and digested by the animal." It is true, as pointed out in previous article,[a] that fermenting manure kills many weed seeds if ey are kept in it long enough, but, as Doctor Jenkins states, common experience fully justifies the belief that the farm may be ocked with weeds which come along with the manure." Many of e weed seeds in the feeds pass into the manure and thence into the lds with their vitality unimpaired. It would appear that absolute urity in this respect can only be attained in all cases by destroying vitality of the weed seeds before they are mixed with the feed. me manufacturers claim to do this, but in none of the feeds mined by the Connecticut Station had the seeds been thoroughly ed.

HOOK-WORM DISEASE OF CATTLE.[b]

his disease, also referred to as bovine uncinariasis and salt sick-, has been reported from Texas, Florida, and South Carolina, is probably widely distributed throughout the Southern States. . Dawson, of the Florida Station, reports it as the most common se of cattle. Investigations by A. F. Conradi and E. Barnett, e South Carolina Station, have shown cattle to be seriously in-d with the hook worm, which is frequently associated with other tinal parasites, including the twisted wireworm or stomach , the inflated bowel worm, and the hair worm. The disease as ibed by Doctor Dawson is "an acute or chronic parasitic dis-nanifested at first by low fever, diarrhea, loss of appetite, soon ing chronic, with continuance of low fever, constipation, loss petite, progressive emaciation, and pronounced anemia, which, ny cases, terminates fatally."

S. Dept. Agr., Farmers' Bul. 334, p. 18.

piled from Florida Sta. Bul. 86; South Carolina Sta. Bul. 137; U. S. gr., Bur. Anim. Indus. Rpt. 1901, p. 183.

Young animals are more susceptible than older ones, but all ages may be affected. The nematode or round worm (*Monodontus phlebotomus*), formerly described as *Uncinaria radiata*, is the exciting cause of the disease. These worms, found principally in the duodenum or first division of the small intestine, are provided with an armature of sharp teeth, by means of which they pierce the lining of the intestines and suck blood, moving from place to place. Other species of hook worm which affect sheep, dogs, cats, foxes, man, and other animals should not be confounded with the species that affects cattle.

The adult worm is from one-half to five-eighths inch in length and of the thickness of an ordinary pin. The eggs are deposited in the intestinal tract and are discharged in the feces, through an examination of which the extent of infestation can be determined. Conradi and Barnett have observed a gorged female whose oviduct contained more than 1,500 eggs, 17 of which were deposited in one hour. At a temperature ranging from 48° to 60° F. forty-one days are required for the eggs to hatch. The life history and habits of the worm have been studied by Conradi and Barnett.

> Upon hatching, the young hook worms are very minute, but can easily be seen with the aid of a hand lens when crawling on the glass walls of the breeding jars. They have a tendency to congregate, and these clusters can be easily recognized with the unaided eye. In this stage, as well as in the egg stage, they are very susceptible to heat or cold, being easily killed. Drought is also fatal, the worms dying in a few minutes. They feed on the fecal matter about them. In the second stage they are but slightly hardier. After several days the body wall becomes thicker and more rigid, and soon they pass to the final larval stage.
>
> The larvæ that were hatched from eggs, gathered from fresh feces on February 26, and hatched February 28, had mostly passed to the final larval stage on March 15. In this stage they are protected by a resistant covering called "sheath." Worms kept in the laboratory during January and February, the temperature varying from 48 to 60° F., passed to the final larval stage in forty-one days. While active they were able to continue feeding through the aperture in the front end of the sheath. They move up and down on any near-by moist object, whether it is earth, grass, leaves, or weeds. They finally become quiescent in some elevated position, discontinue feeding, and are then greatly resistant to heat, cold, and drought. This habit of rising appears to be advantageous, as, we believe, the principal method of host infestation is through the mouth.
>
> That part of the life history from egg to larval stage is very probably completed in a few days during the warm weather of summer.

The eggs and young worms require moisture. It seems quite probable that little development takes place in feces dropped on a hill during the drought of summer. There is said to be little danger from infestation in running water.

At present the outlook for a cure for this disease is not very encouraging. Thymol has given good results in the treatment of the disease in man, and has been recommended by some authorities for the disease in cattle and sheep, but we believe it is far from being a specific. Certainly, in the case above referred to, with a dose of 150 grains, it could not be noticed that the worms had been in the least affected three days later. However, further experiments with this drug will be made as opportunity presents itself. Even if drugs such as thymol were effective in expelling the worms, the animal, if still pasturing on infested land, would continue to reinfest itself, so that the problem resolves itself into a question of prevention rather than treatment, the outlook for which is more encouraging.

When it is remembered that the disease occurs chiefly, or altogether, on low, wet lands, and that in dry seasons it is less severe, it would appear that much could be done by avoiding such places as pastures for at least one year. The land should be thoroughly drained, and it would be well to liberally apply air-slaked lime to accelerate drying. If in hook-worm infested lots the droppings are gathered every day, it will decrease the infestation.

Plowing, undoubtedly, also reduces the dangers of infestation, as heavily infested material buried 3 inches in loose, pulverulent, moist soil in the laboratory showed that a little over one-third as many larvæ ascended on the glass wall of the breeding jar as in the jar used as a check where an equal amount of material from the same droppings was left on the surface of the moist soil.

It is recommended that on hook-worm infested farms annual crop rotation be practiced as far as possible. The manure should be removed from stables occupied by infested animals daily and air-slaked lime used liberally to dry up the floors. The greatest precaution should be exercised to prevent the spread of this parasite into localities where it does not yet occur, either by shipments of infested cattle or otherwise.

Where it is desirable to eradicate this pest from a lot previous to putting in animals that are not infested, it may be accomplished by burning. For this purpose one should have a good substantial spray pump fitted with hose, extension rod, and a fine nozzle. Either kerosene or gas oil may be used. After the pump is filled and set in operation the spray is ignited near the nozzle. The present price of kerosene, however, would make this operation too expensive over large areas.

EFFECT OF MACHINE MILKING ON INDIVIDUAL COWS.[a]

Owing to the rapid growth of the dairy industry in recent years and the increasing difficulty of securing competent help, much interest has been aroused in the possibility of securing greater economy in time and labor by the use of mechanical milkers. Several of the experiment stations, as well as the Dairy Division of this Department, have made experiments and published reports dealing with various phases of this subject.[b]

At the Nebraska Station, A. L. Haecker and E. M. Little have been carrying on experiments for several years with a view to ascertaining definitely some of the practical limitations of the milking machine and the conditions under which it may be most successfully used. These experiments have dealt more particularly with the effect of the use of the milking machine upon the production of cows throughout the lactation period and the behavior of individual animals with reference to machine milking.

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[a] Compiled from Nebraska Sta. Bul. 108.

[b] Connecticut Storrs Sta. Bul. 47; Kansas Sta. Bul. 140; Pennsylvania Sta. Bul. 85; Wisconsin Sta. Bul. 173; Ontario Dept. Agr. Bul. 159; U. S. Dept. Agr., Bur. Anim. Indus. Bul. 92.

In the experiments 53 different cows have been milked by machinery. Of these cows some have been milked continually with the mechanical milkers from the time they were first tried, while others have been subjected to this method for only a short time. As a result, twenty practically complete lactation records have been obtained, together with numerous records covering shorter periods of time. * * *

In 1908 an experiment with 10 heifers was begun which will cover a series of years. These animals have never been milked by hand, so their performance, as far as milking is concerned, will be entirely controlled by the milkers. So far, two lactation records by heifers have been obtained by machine milking which compare favorably with other 2-year-old records made in the University dairy. Heifers in their first lactation seem to give down their milk quite freely when milked by machine and are less inclined to hold up milk than are cows which have been accustomed to hand milking for several years before machine milking is begun.

In general it was found that the effect of the machine varied with the individual cows, and that some cows are not adapted to machine milking. Heifers in their first lactation apparently gave better results by machine milking than did aged cows that had been accustomed to hand milking for one or more years.

With animals adapted to the purpose, the use of the milking machine appears, according to the Nebraska Station experiments, to be of very decided advantage, but if there are several animals in the herd which can not be milked in this way to advantage the herd totals may be so lowered, and the resultant losses become so great, that they would not be compensated for by the saving of time and labor in the use of the machine.

The successful application of machine milking can not therefore be assured "until all the members of the herd are known to be adapted to this method of milking."

MILK SUPPLY OF CITIES.[a]

The widespread and constantly growing interest in the subject of a supply of pure milk has led to an investigation of the subject at several of the stations.

There are three classes of persons responsible for the condition of milk as it finally reaches the human stomach, namely, the producers, the dealers, and the consumers. The importance of the first two classes in keeping a milk supply pure and wholesome has been recognized by all investigators, but that the consumers have a duty to perform seems to have escaped the notice of many observers. This phase of the subject has been discussed by J. M. Trueman, of the Illinois Station, as follows:

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[a] Compiled from Illinois Sta. Bul. 120; Kentucky Sta. Bul. 134.

> Not only the producer and dealer but the consumer has something to do in securing a supply of clean, sanitary milk. He should appreciate the superiority of good milk, should know what such milk is and which dealers are selling it in his city. Every dairyman who tries to meet the modern requirements of good milk should be given trade in preference to the man who is wedded to unsanitary customs. Many a consumer will use the product of poor cows handled in unsanitary buildings, rather than pay a cent or two more per quart for clean, safe milk. This is a direct bid for poor milk.
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> If the consumer would visit the dairies of his city and find out for himself how the milk is handled it would result in good to all concerned. A number of milkmen have admitted that they would be ashamed to let their customers see how the milk is produced. An intelligent demand for clean milk would go far to improve the situation. It would at least set the dairyman to thinking if a few questions like the following were asked him:
>
> "Are all your cows healthy?" "Do you keep them clean?" "Is your barn light and well ventilated?" "Are your bottles sterilized each time before filling?"
>
> If, in making a round of the dairies, the consumer should find an up-to-date, sanitary place and see the extra care taken to produce good milk, it is very likely he would be willing to pay a little more money for such milk.
>
> The consumer is often to be blamed for the milk souring quickly. First-class milk, left at his home in a clean bottle and at a low temperature, may be sour or off flavor twelve hours later because it was left standing in a warm kitchen for a few minutes, or was poured out into a pan that had been washed in the dish-pan and wiped on a towel that had done service for all kinds of dishes for several days. Milk should not be left standing in the sun a minute after the milkman leaves it. The consumer should have a place for the milk inside the house or in the shade, and should see that the deliveryman puts it there. It should be taken immediately to the coolest place in the house and left in the bottle without removing the cap until wanted for use, or he can not blame the milkman if the milk spoils. The consumer does not deserve good milk unless he discriminates in favor of such milk and takes the proper care to keep it good after it reaches him.
>
> At present prices the cost of milk produced in Illinois in such a manner as has been recommended here should not much exceed 8 cents a quart delivered, and at this price it is cheaper food than meat. It can not be produced and delivered for 5 cents; 6 cents leaves too small a margin of profit for the honest dealer; 7 cents will do in many localities. However, these prices do not apply to special or fancy milk. When the people insist on having good milk and are willing to pay a fair price for it, the milkmen will fall into line quickly and supply the demand.
>
> In one case a dairyman advertised the exact way in which he produced clean milk, and offered it at 2 cents per quart above the regular price. Soon he found more customers than he could supply.

Taking up the question of the methods of the dealers in handling milk and its products, Professor Trueman found in Chicago in 1906[a] much to criticise and less to commend.

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[a] It is reported that conditions have since been improved.

It was an exception to find a milk depot that was clean and sanitary. A great many of these markets are located in dark, dirty, and ill-ventilated basements where the sunlight never enters. They are never scrubbed out, and many of them could not be scrubbed clean because the floors are of rotten wood or only of earth, and so they are kept foul with sour and decaying milk. These depots would be bad enough if they received only bottled milk and sold it without opening the bottle, but commonly the milk is stored in large cans, dipped into open vessels when sold, and often carried through dusty streets for several blocks. Such conditions are deplorable. Occasionally, but rarely, one of these small depots is found scrupulously clean.

In the better portions of the city much of the milk is delivered from wagons, and a large part of it by big dealers. This milk is uniformly up to grade in butter fat, but the amount of sediment in the bottom of the bottle is occasionally quite large. If all parts of the city were furnished with as good milk as the wealthy people receive, very little cause for criticism would exist. It is not primarily a question of price, as the greater part of the best milk sold in the city retails at from 7 to 8 cents; while the poor milk sold to the working people from open cans brings 6 cents. It is cause for congratulation that an increasing proportion of the working people are being supplied with clean milk in sterilized bottles. The small depot, although it keeps the milk cold for the poor people who have no ice box or cellar and enables them to buy in small quantities, is a doubtful blessing. The best of the big dealers furnish a much better quality of milk at a moderate price, and it may be kept sweet in a cool cellar for the day's consumption.

Of samples of milk collected in a residence district of rich people and well-to-do artisans only 9 per cent of the milk was found below grade, while in the poorer district 50 per cent of the milk was below grade.

The richer district was for the most part served by the wagons of the best large dealers, who always handle a good grade of milk. The fact that 9 per cent was found below grade shows that there is still room for improvement. The amount of sediment found here was much less than in the poorer districts, but it was by no means entirely absent. The noticeable thing revealed * * * is that the poor people who needed the best of nourishment paid almost as much for poor milk as the rich people paid for good milk. * * *

The milk as it comes from the country is almost universally up to grade. It will average 3.5 to 4 per cent of butter fat. The small dealer buys one or more cans at the platform when the train is unloaded, takes the milk to his depot, and sets it in a tank of ice water. The cream rises in the can, and before beginning to sell the milk the dealer removes one or two quarts of cream, which is sold in small quantities at a good price and furnishes the larger part of the profit. The milk remaining in the can is stirred up and sold as whole milk at 6 cents per quart. Frequently water is added to take the place of the cream removed.

The temptation to make profits in this way overcomes any system of inspection that the city has yet established in these districts. By this means the poor are defrauded by people of their own class, and half-nourished children are fed on skimmed and watered milk for which full price has been paid.

That conditions in Louisville are no better is well shown by R. M. Allen in a recent bulletin of the Kentucky Station. He says that "only a small percentage of the milk comes into the city bottled."

He also touches on the question of the unequal distribution of the returns from the sale of milk. The producers have a great deal more invested in proportion to product, and yet they receive on an average probably from one-fourth to one-third of the price paid by the consumer. The balance goes for transportation and distribution.

The following [is a report of] an inspection of the principal milk depots, and in addition some clean and unclean places selected from the grocery and fruit stores where the milk is kept "to accommodate the customer." It has been the experience not only in this milk inspection, but in all pure-food work that many of the grocery stores are very unsanitary places. This inspection shows in the majority of instances unclean refrigerators, or milk kept in refrigerators with vegetables and other products, and often the situation of the refrigerator near oil tanks and so on, in the midst of general dirt and rubbish. There were, however, a number of clean stores. The retail grocery store by reason of its ice boxes and other conveniences is a necessary adjunct to the community, else many of them would not be tolerated in their present filthy state. It should not take much argument to convince anyone that the retail grocery store would become more necessary and profitable if cleaned up and kept cleaned, and provided with all of the systems and means necessary for keeping and protecting perishable food.

The general milk depots may be grouped into five classes: (1) The depots owned and operated by the dairymen themselves; (2) the depots which are supplied by dairymen under contract to maintain sanitary barns, to use covered pails, and to cool the milk before shipping; (3) depots in which the milk is pasteurized and which are supplied from sources with a less regard for sanitary conditions; (4) depots supplied with an inferior milk from any source possible, and with which the patrons have no steady contract; (5) the ice-cream plants which sell milk. The milk is shipped or delivered to these depots in cans holding from 2 to 10 gallons. Some of the dealers empty these cans at once, wash and steam them, and return promptly to the dairymen. Others return the cans unwashed, and still others use the dairymen's property for further handling of the milk among their trade, and the can, after a week's use or delay, is finally returned to the owner foul and filthy. The dairymen as a rule have not the facilities for steaming and sterilizing cans which a milk depot by reason of its volume of business should maintain. Attempt is made by the dairymen, however, to wash the foul cans on the farms, but such a can is not fit for use again unless it has been aired for several days, and it is frequently necessary to use it at once because the dairymen's full supply of cans have either not been returned promptly or have been misplaced in shipping. The only way to remedy this problem is to require the milk dealer under the penalty of an ordinance or a law to return the cans promptly, and to return them clean and sterilized.

The system of distributing milk out of wagon cans from house to house can not be too strongly condemned. It matters not how cleanly the milk may be produced or with how much care it is delivered to the city, if finally distributed to the consumer in this way. The can top is opened to dip out the consumer's amount. This is put into the open top or bucket, which is again emptied into the consumer's pitcher or crock. All [this is] done in the open dusty street. Among all sources of contamination there is none from which comes more opportunity for dirt and disease than the distribution of milk in open cans from the street. And among the regulations most needed is one to compel all milk to be delivered to the consumer in the original package. This would mean the bottling of all milk for retail trade on the farm, or delivered in cans to consumers purchasing a gallon or more, and in cans to ice-cream factories, bakeries, and other places where milk is used in wholesale quantities.

It will be seen from this that much improvement is to be made in the milk depots as well as in the dairies if the city is to have pure milk. There is too much handling of the milk in the city depots, and the mixing of milk from good and bad herds together is another objectionable feature. The cost of distribution is also excessive, in fact, is from two to three times the price paid the dairyman for milk, while the investment in farm, equipment, herd, feed, labor, and shipping in 100 dairies is many times the investment necessitated in the one city depot which distributes the milk. The city plants should really be nothing more than a distributing point for the handling of milk in the original bottles or cans as it comes from the farm. And if such were the case, and if cooperative distributing plants were organized, there would be more profit to assist the dairymen in maintaining cleaner and better barns and milk houses, and this profit would come without much advance to consumers in the price of milk, besides the protection from city contamination. In addition to this, depots established under city or some charitable aid are necessary to distribute pure milk to the poorer classes of customers, and thus by eliminating a large part of the cost of distribution make it possible for such customers to have pure milk at a price within their reach. Rochester's system of depots maintained in this way has proven not only in every way practicable but has had a direct effect in decreasing the rate of infant mortality.

It would seem that in smaller places conditions should be better, inasmuch as producer and consumer are in closer touch with each other, but the contrary seems to be the case. Perhaps one reason is that the milk reaches the consumer in so much shorter time, and therefore the effect of careless and unsanitary methods has not had as great opportunity to develop. On this point Professor Trueman says:

> The milk conditions in the 26 smaller cities visited were found less satisfactory than in Chicago. Much more formaldehyde was discovered and a larger proportion of samples contained sediment. A great deal of criticism is always heard of the food supplies of large cities. But the chances of getting good milk, by anyone who knows the requirements of such milk, are better in Chicago than in any of the 26 cities of 10,000 to 60,000 population in Illinois. Here again is shown the good that may be accomplished by inspection. The majority of the smaller cities have little or no inspection, and the dairymen and dealers have failed to bring the milk up to a high standard. The percentage of butter fat averages higher than it does in some districts of Chicago, but the amount of sediment is very large.

From all the foregoing facts it appears very evident that all the blame for poor milk is not properly charged to the farmer. While it is true that good milk can not be produced except by strictly sanitary dairy methods, it is equally true that milk which leaves the dairy in the best possible condition may become contaminated and unfit for food before it is used. This does not, however, relieve the farmer of any responsibility for his part in the production of pure milk, but rather makes it incumbent upon him for the sake of his own reputation to see to it that he disposes of his product to dealers who will use equal care to keep it pure.

While it costs more to produce clean milk the returns will in the long run more than repay the added expense, and, besides, it is not so much a question of an expensive outfit as it is one of being careful and cleanly. The requirements for clean, healthful milk are stated by Professor Trueman as follows:

All cows that are weak, extremely thin, and coughing must be removed from the herd. Milk from unhealthy cows is not safe to use, and only cows in good health can make profitable use of the food given them. The herd should be inspected at regular intervals by a competent veterinarian.

It is necessary to have healthful buildings and to keep them clean, but such buildings need not be expensive. The four essentials are light, ventilation, a proper floor, and a comfortable tie. Window glass is almost as cheap as lumber. The King system of ventilation can be installed by any carpenter or by the farmer himself at the cost of a few feet of lumber and a few days' work. A cement floor is but little more expensive than a good wood floor, and is many times more durable. Planks laid over the cement where the cows stand will prevent injury to the animals. A comfortable tie is only a little more expensive than an awkward rigid stanchion. A good swing stanchion is not uncomfortable to the cow. All of these things could be put into the ordinary Illinois barn with but little trouble, and would pay for themselves in less than a year in the increased efficiency of the herd.

Much of the dirt in milk comes from the barnyard. The cows wade knee deep in mud and manure and carry this filth into the barn on their legs, tails, and udders. It is difficult to clean off, and the careless milker makes little attempt to prevent the constant shower of dirt falling into the pail. The yard should be well drained and graded up with cinders or gravel. If drainage can not be obtained in any other way, the rule should be, raise the barn and grade up to it.

Before milking, the cows should be gone over with a brush and all loose particles of dirt removed. This need not take more than thirty seconds per cow. The cow's udder comes in contact with the floor and can not be cleaned by simply brushing. It is very important that the udder should be washed with a damp sponge or cloth, and this may take thirty seconds more. The sponging will be doubly effective if the long hairs around the teat and lower part of the udder are cut short. Each man who is to milk twelve or fifteen cows will need to spend twelve or fifteen minutes in cleaning them. This cleaning is very simple and inexpensive, and yet nine out of ten farmers scout the idea as preposterous. Every farmer will spend hours cleaning his horses, because he is ashamed to have the public see them dirty. It would be much more reasonable to spend less time cleaning his horses and more time cleaning the animals that produce the milk his children are to drink. It is time for the consumer to demand that every individual dairyman supplying milk for city consumption shall use at least common decency in its production.

Clean cows, clean clothes, and clean dry hands for the milker should be the unvarying rule of every dairy. Special milking suits should be worn and frequently washed.

A small-topped pail would prevent a large amount of dirt from falling into the milk. Pails, cans, strainers, coolers, and every other utensil that comes in contact with the milk should be washed clean and sterilized. Sterilizing means heating to 212° F. It may be done by boiling water or by steam. It can not be done by starting with boiling water in one can and pouring it from can to can to clean half a dozen. The easiest way to do thorough work is to use steam.

The ideal method for preparing the milk for delivery is that it shall be cooled to 45° F. immediately after milking in a clean dairy room separated from the stable, and then bottled in sterilized bottles and the bottles sealed with paraffined paper caps. This method, however, involves quite an outfit, and would usually require a supply of ice. In case of small dairies too far away from their market to retail their own product the next best method would be to take the milk immediately to a bottling plant, where it is cooled and bottled as noted above, and then shipped to the city either packed in ice or in refrigerator cars.

In recent years milk commissions organized by county medical societies have made it possible to secure for the use of invalids and for the artificial feeding of infants a supply of milk that is extremely pure and wholesome. The milk produced under such supervision is called certified milk, and the name is protected by registry in the United States Patent Office. However, this does not prevent its use by duly organized commissions. The work of such commissions and the production of certified milk have been discussed in considerable detail in a recent bulletin of the Dairy Division of this Department.[a]

The following statement is made of the composition, bacterial content, and value of certified milk as compared with ordinary market milk:

> As far as the chemical composition is concerned, certified milk does not differ materially from ordinary market milk. The milk commissions require that the fat and total solids shall come within certain limits, and for this reason there is but little variation in the chemical composition of certified milk. The standards are not high, for the reason that milk containing about 4 per cent of fat is considered to be the best for immediate consumption. As stated elsewhere, many of the herds in certified-milk dairies are composed of grade cows and do not produce milk of more than the average richness.
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> When we compare the bacterial content of certified and market milk we find a very striking difference. The bacteria in the average milk supply of our large cities exceed 500,000 to the cubic centimeter, while the bacteria in certified milk seldom exceed 30,000 to the cubic centimeter and in most instances average less than 10,000. There have been some cases where commissions have reported that no bacteria were shown to be present by the ordinary methods used for their detection. Liquefying, putrefactive, and pus-forming bacteria are seldom present in large numbers; in fact, the contracts of some commissions with the producers specify that the milk shall not contain pathogenic bacteria or more than a limited number of pus cells to the cubic centimeter. * * *
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> Certified milk, produced under the direction of a reliable milk commission, is worth more than ordinary market milk for several reasons: (1) It is free from disease-producing bacteria, and all other germs are reduced to a minimum. (2) It is free from high acidity and pathogenic germs which lead to stomach derangements and kindred troubles. (3) The customer can always depend upon his milk coming from the same farm, the same herd of cows, subjected to the same treatment, and having the same quality. The fat content is guaranteed not to vary outside of narrow limits; hence the milk is always of good

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[a] U. S. Dept. Agr., Bur. Anim. Indus. Bul. 104.

quality. (4) Cleanliness and cold are the only preservatives used. (5) It is a safe food for infants and people with delicate digestion. (6) It is the natural product of the cow, and has not been subjected to any treatment which affects its digestibility or changes its character. (7) It is reasonably free from foreign odors and objectionable flavors.

The extent to which milk and its products are used as food and the influence which the purity of milk has on the health of the consumers have led to an extensive investigation of the relation of milk to the public health. This investigation was carried on by the United States Public Health and Marine-Hospital Service in cooperation with the Bureaus of Animal Industry and Chemistry of this Department. The results have recently been published in a very comprehensive report.[a]

The purpose of the investigation was to secure "all available data showing the influence of milk as a carrier of infection, its chemical composition, the contaminations found therein, their influence upon it as an article of food, and the measures necessary in its production and handling to prevent such contamination."

As regards milk supply, the conclusion was reached that "it is evident, from a broad view of the subject, that a pure and wholesome milk supply is possible," and it is stated that the report contains all the necessary information to attain that end, as well as the existing standards of purity to which it should conform.

"The three cardinal requirements—cleanliness, cold, and speedy transportation from the cow to the consumer—must be observed, and the cow herself must be free from disease. For their observance, intelligence and care on the part of the dairyman and milk dealer are absolutely essential."

In the report of a previous conference appointed by the Commissioners of the District of Columbia,[b] a classification of commercial milk was proposed by A. D. Melvin, chief of the Bureau of Animal Industry of this Department, which seems applicable to the milk supply of any city. Doctor Melvin recommends "that the milk supply of the city be divided into three classes." Class 1 is to be certified milk, essentially as previously specified (p. 26).

Class 2 to be clean, raw milk from healthy cows, as determined by the tuberculin test and veterinary physical examination; the cows to be housed, fed, and milked under good conditions, but not necessarily equal to the conditions provided for class 1; pure water, as determined by chemical and bacteriological examination, to be provided; the bacteriological count of the milk not to exceed 100,000 bacteria per cubic centimeter at the time the milk reaches the city at any season of the year, as determined by the health department at frequent intervals; milk to be delivered to the customer in sterilized containers, and the temperature of the milk not to exceed 50° F. until delivered to the consumer.

Class 3 to be milk from all other dairies not able to comply with the requirements for classes 1 and 2, this milk to be clarified and pasteurized at central pasteurizing plants, which shall be under the personal supervision of an officer of the health department. These pasteurizing plants may be provided either by private enterprise or by the District government, and should be located within the city of Washington. Class 3 milk should not be permitted to exceed 60° F. on delivery from the dairy to the pasteurizing plants. The milk from these pasteurizing plants, placed in sterilized containers, should be delivered to the consumer at a temperature not exceeding 50° F. All milk of unknown origin should be placed under class 3 and subjected to clarification and pasteurization. It should also be provided that no cows suffering from any communicable disease or any unfit condition, to be determined upon physical examination by an authorized veterinarian, shall be permitted in any dairies; and, further, that cows which do not show any physical signs of tuberculosis upon veterinary examination, but which may have reacted to the tuberculin test, may be included in dairies supplying milk of this class.

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[a] Pub. Health and Mar. Hosp. Serv. U. S., Hyg. Lab. Bul. 41.

[b] U. S. Dept. Agr., Bur. Anim. Indus. Circ. 114.

No dairy farm should be permitted to supply milk of a higher class than that for which the permit has been issued, and each dairy farm supplying milk of a specified class should be separate and distinct from any dairy farm of a different class; the same owner, however, might supply different classes of milk, providing the dairy farms are separate and distinct, as above indicated.

All milk to be of good composition, free from adulterants and artificial coloring matter.

The term "milk" to include both milk and cream.

It seems evident from a consideration of the foregoing that what is especially needed is a better knowledge on the part of producer, distributer, and consumer of milk of the necessity for intelligent care and absolute cleanliness in producing and marketing this valuable product.

THE CROW AS A MENACE TO POULTRY RAISING.[a]

Discussing this subject in a report of the Rhode Island Station, L. J. Cole says:

That the common crow (*Corvus brachyrhynchos*) is a not infrequent despoiler of the nests of other birds has long been known, while his attacks upon poultry and eggs were among the grievances held against him by the early settlers. It is, perhaps, not generally appreciated that the crow is distinctly omnivorous, and that under natural conditions a large proportion of its food consists of animal matter. According to Barrows and Schwarz, roughly speaking one-third of the food of crows consists of animal matter; during certain months, especially April and May, the proportion of animal food consumed is nearly double, while in the fall and winter it is correspondingly less.

The crow's depredations upon poultry consist almost entirely in the destruction of eggs and the killing of the young. Adult fowls are probably seldom attacked, unless sick and weakened. The eggs of the turkey, which is commonly allowed to roam and select its nesting site far removed from the house or poultry yard, are especially liable to destruction by crows. They do frequently, however, attack chicks, young turkeys, and even goslings. * * *

Serious depredations of crows upon poultry and eggs appear to occur only in certain localities, while in other places, though the crow may have an unsavory reputation, as he generally does in farming communities, he is at least free of this opprobrium. The reasons for this are probably twofold, depending first, upon the abundance of other food, and, in the second place, upon the accessibility of poultry. As poultry raising is now generally conducted, when any special attention is given to it, the eggs are no longer exposed to the danger from crows, since the hens lay in regularly appointed houses. Furthermore, the young chicks are, as a rule, much better protected, being confined in yards and runs near the house, instead of being allowed to roam at large with their mothers. Nevertheless, * * * the crows may become very daring in their attacks when other food is scarce. The necessity of an abundant supply of food is especially great during the months of April and May, when the crows are rearing their young. * * * Since young chicks are usually raised at about the same time, it is evident why they often furnish a very acceptable addition to the crow's larder.

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[a] Compiled from Rhode Island Sta. Rpt. 1908, pp. 312–316.

Attention is called to two cases of persistent depredations by crows, which caused serious losses to poultrymen in Rhode Island. In one case, 25 per cent of the chickens hatched were destroyed by crows between April 1 and July 10.

All sizes were taken, from the time they were just hatched until they were a pound in weight. The larger chicks the crows killed and ate where they caught them, but the smaller ones they carried away in their beaks. Various efforts were made to keep the crows away, most of which were ineffectual. The first was a scarecrow, but this had little or no effect. In the second place, corn soaked in strychnin solution was scattered on a field of planted corn at a little distance from the chicken yard. This may have killed some crows, but no dead ones were found. No corn was pulled, but there was no appreciable decrease in the number of chickens taken. Third, a steel trap was set on a pole near the chicken yard, but without success. Fourth, white twine was run on stakes around and across the chicken yard; this kept the crows from the yard, but the small chicks would get out, and would then still fall a prey to the crows. Finally, a crow was shot and hung on a pole near the chicken yard, after which there was no further trouble.

In the other case cited, 87 per cent of ducklings hatched were destroyed by crows. In this case, also, a scarecrow was ineffectual in keeping the crows away.

The question of whether the crow is on the whole beneficial to agricultural interests or whether he does more harm than good, is one that will probably have to receive a different answer in accordance with different conditions. That he does a great deal of good at times by the destruction of noxious insects can not be denied, though it would probably be difficult to convince the average farmer that he is anything but a thief and a rascal. The problem is in reality an extremely complex one, depending upon a great many variable factors, especially the absolute and relative abundance of various kinds of food. When other food is scarce the crow turns to poultry, but when certain insects (such, for example, as the beetles commonly known as "June bugs") are abundant, the crow feeds largely upon them. * * *

Whatever may be the crow's good points in particular cases, it is not likely that the poultryman who is suffering serious losses by his depredations will be inclined to look upon him with favor. * * *

It should, perhaps, be mentioned that it is the opinion of many observers that the egg and poultry stealing habit is not common to all of the crows of even a single locality, but that the habit is acquired by certain individuals only, and that if these can be shot the trouble will be stopped.

HOURS OF LABOR, WAGES, AND COST OF BOARD ON MINNESOTA FARMS.[a]

In connection with an exhaustive study of the cost of producing farm crops and of feeding and caring for live stock on Minnesota farms, statistical data have been collected regarding the hours of labor, the cost of farm labor, and the value of the food of the family, including both the articles purchased and the articles produced on the farm. These statistics are of interest in themselves and are also an essential part of the discussion of the cost of producing farm crops and stock.

Farms were selected first in three, then in five, counties in western, northwestern, southeastern, and southwestern Minnesota, and data were systematically gathered in a number of farm homes in these counties. The investigations were instituted by Assistant Secretary Willet M. Hays (then professor of agriculture at the Minnesota College of Agriculture) and have been carried on by the Minnesota Experiment Station cooperating with the Bureau of Statistics of this Department.

According to E. C. Parker and T. P. Cooper, who reported the latest of these investigations, the average monthly cash wages of farm laborers on the selected farms for the years 1904–1907, during the eight "crop-season" months, April 1 to November 30, were approximately as follows: Northfield, Rice County (1905–1907), $26.16; Marshall, Lyon County, $26.64; Halstad, Norman County, $25.56, and a large farm in northwestern Minnesota, Norman County, $26.77. During the months of December, January, February, and March the average monthly wage at Northfield was $15.80; Marshall, $14.20; Halstad, $11.69, and the large farm in northwestern Minnesota, $14.36.

The average cash value per hour of farm labor on all the farms, for the three years 1905–1907, was 11.2 cents for December, January, February, and March, and 12.7 cents for the "crop-season" months, April to November, inclusive. While wages are lower in the winter months, the number of hours of labor is much less than in the summer, thus there is little difference between summer and winter in the cost per hour for farm labor. This cost is based upon the wages paid to men plus the cost for board.

The average number of hours worked per day by men (1902–1907) on the farms at Northfield, southeastern Minnesota, was 8.94 hours, with 3.64 hours for Sunday work. At Marshall, in southwestern Minnesota, 8.66 hours for week days and 3.05 hours for Sundays, and at Halstad, in northwestern Minnesota, 8.10 hours for week days and 2.76 hours for Sundays. No estimate is given of the average length of the working day of the women on these farms.

The statistics summarized show that on an average the total value of the farm produce used per family was $222.97; of groceries and fuel, $170.89; of man and horse labor, $57.74; of women's labor, $216.66, and of house furnishings, $32.46 per year, women's labor representing 30.91 per cent of the total cost, the largest single item with the exception of farm produce, which was 31.81 per cent of the total.

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[a] Compiled from Minnesota Sta. Bul. 97; U. S. Dept. Agr., Bur. Statis. Buls. 48, 73; Jour. Home Econ., 1 (1909), No. 1, pp. 43–51.

In estimating the cost of board per man per month record was kept of the food, including groceries, meat, farm products, etc., fuel, garden produce, including cash cost of seeds, labor, rent of land, etc., the labor of men in the household, and labor of women in the household. Record was also kept of the number of persons who were boarded and the number of days each was boarded.

Assistant Secretary Hays and E. C. Parker make the following statements regarding this part of the work:

> In determining the cost of board on farms per day and per month, it is necessary to figure the total cost of the table board each year, and then divide this sum by the total number of days' board in terms of one man. It is impossible to figure this cost of board month by month during the year, because the purchase of supplies may be great one month and very small the next month. Inventoried supplies of flour, sugar, farm produce, etc., are consumed during a number of months, and the exact amount consumed each month can not be determined. Cost of board per month per man is, therefore, figured from a yearly average, and the data secured * * * are used in determining the rate of wages per hour. * * *
>
> Wages for household work are not actually paid on a majority of farms, but a yearly cash value is placed upon the household work on each farm, so that the cost of board may be reduced to cost per month per man and be used in determining rates of wages for man labor. The amount of wages * * * [assigned] in each case is determined by the standard of living, the size of the family, and the prevailing wages for housekeepers and hired women.

The average cost of farm board per month of one laborer for the three years 1905–1907 was, according to the figures summarized, $14.36 at Northfield, $12.73 at Marshall, $11.58 at Halstad, and $10.02 on the large grain farm in northwestern Minnesota. "The average cost per day was 47.9 cents at Northfield, 42.4 cents at Marshall, 38.6 cents at Halstad, and 33.4 cents for the large farm in northwestern Minnesota; the average cost of board per month on all farms was $12.65, and per day 42 cents."

An important factor in determining the cost of board on farms is the proportion of home-grown material and purchased foods which is used. The table which follows shows the average quantity of farm produce other than vegetables used on the various farms.

Average annual consumption of farm produce per man on certain Minnesota farms.

Location of farms.	Whole milk.	Skim milk.	Butter.	Cream.	Eggs.	Pork.	Poultry.	Beef.	Mutton.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Dozen.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Northfield	333.2	....	19.1	16.8	61.8	94.4	22.6	....	....
Marshall	241	298.9	68.5	90.1	46	77.5	24.9	28.4	4.1
Halstad	48.2	718.1	52.2	84.7	26.3	60.1	6.8	118.2	2.2

According to T. P. Cooper's discussion of this subject—

> The values given in the table afford a good illustration of the quantity * * * of the farm products used per man, and show the great difference in the dietary of the farmers in the southeastern part of the State and those in the northwestern. At Marshall a larger amount of butter was made and consumed on the farm than at Northfield and a considerably larger amount of cream, meats, etc., were used, while the quantity of eggs and pork used was smaller. At Halstad as at Marshall there was a tendency to make a greater use of products produced at home. The saving shown in the amount of butter and eggs used per man is possibly due to the fact that they have a ready cash sale, but is more likely due to the use of certain substitutes which are cheaper or more easily secured.
>
> No skim milk (that is, milk from which the greater part of butter fat has been separated, but which still contains about one-tenth per cent fat) was used on the Northfield route, but a large quantity was used on the Halstad route and but very little whole milk. The quantity of cream used on the Marshall route is large compared with Northfield, 90 pounds against 16 pounds, but the quantity of whole milk consumed was less. In 1907 only two farms on the Halstad route used whole milk. However, the loss of fat in the whole milk was made good by the use of cream and the skim milk. The cream commonly used on these farms contains from 20 per cent to 30 per cent butter fat.
>
> It is of interest to note the great dependence placed upon dairy products on the Marshall and Halstad farms. There, the milk, cream, and butter used assume a prominent place in the family diet. As no milk or cream is purchased, the quantities of milk used indicate in a way the dependence of the farm family on the different routes upon these products. At Northfield 349 pounds of milk and cream are consumed per man per year, while at Marshall and Halstad the amounts are 630 pounds and 851 pounds, respectively. The farm at Halstad, then, provides almost two and a half times more milk and cream per man per year than the farm at Northfield.
>
> The farms at Halstad furnish annually 187 pounds of meat per man per year, those at Marshall 134 pounds, and at Northfield 117 pounds, the housewife at Northfield being more dependent upon the butcher than are those of Marshall and Halstad. The smaller quantity of meat from the farm used at Northfield is probably due in part to the fact that the average number of persons boarded is insufficient to consume fresh meat during the warm months and in part to a distaste for the preserved products. The value of the farm produce used at Halstad and Marshall is about one-third of the total cost of board, which illustrates the old saying that the farmer obtains one-half his living from the farm. If labor and furnishings are not considered, the farm, as determined by cost, furnishes 44 per cent of the living at Northfield, 53 per cent at Marshall, and 56 per cent at Halstad. If food values are taken into consideration, a much higher proportion would be furnished from the farm. A large proportion of the expenditures for groceries is for items having a slight food value best used for condimental purposes and for furnishing pleasant changes.
>
> If a people are known by their dietary, we may look upon the farmer of Minnesota as being an exceptionally well-fed individual and consequently having a high labor efficiency. This view is undoubtedly correct, for while the average number of hours of labor by the farmer is not excessive, yet a visitor is usually impressed with the amount of work accomplished.

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LIGHTNING AND LIGHTNING CONDUCTORS.

BY

ALFRED J. HENRY,

Professor of Meteorology, Weather Bureau.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Weather Bureau,
Office of the Chief,
Washington, D. C., June 12, 1909.

Sir: I have the honor to transmit herewith a paper entitled "Lightning and Lightning Conductors," by Alfred J. Henry, professor of meteorology. This paper contains information respecting the phenomena of lightning in general and suggests means of protecting farm buildings from destructive lightning strokes. It is recommended that it be published as a Farmers' Bulletin.

Respectfully,

W. L. Moore,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction........ 7
Origin of electricity........ 8
Conductors and nonconductors........ 8
Positive and negative electrification........ 8
Electricity in thunderstorms........ 11
Lightning rods for farm buildings........ 14
  Material........ 14
  Directions for putting up wires........ 16
  Terminals........ 17
  Earth connections........ 17
  Buildings with metallic roofs........ 18
  Painting........ 20

ILLUSTRATIONS.

Page.
FIG. 1. Method of placing lightning rods on a building having no cupola or chimney. Length of building, about 25 feet........ 14
2. Two types of T connections........ 16
3. Showing method of running horizontal conductor around a chimney or cupola........ 17

LIGHTNING AND LIGHTNING CONDUCTORS.

INTRODUCTION.

If the phenomenon of lightning were better understood, perhaps the enormous toll it exacts in life and property would be less. Carefully compiled statistics show that in the United States between 700 and 800 persons are killed annually and twice that number injured by lightning. This great loss of life falls largely upon the people who live away from the great centers of population. So, too, the greater part of the annual loss of property is chargeable to farm buildings and their contents and live stock in the field. Light and power electrical transmission lines also suffer from the vagaries of lightning, but the great multiplication of these lines in recent times has stimulated the development of means of protection, so that nowadays the electric power plants and lines are better protected from lightning than are farm buildings.

In what follows an attempt will be made to outline in nontechnical language a few of the most important laws of electrical phenomena. It is obvious that even a rudimentary knowledge of matters concerning the behavior of electrically charged bodies under various conditions will be of high value to persons who spend the greater portion of the day in the open.

Lightning, or more particularly a lightning flash, is a discharge of electricity between two electrified bodies, as between one cloud and another or between a cloud and the earth. Most of us are familiar with electricity and the varied economic purposes it serves. In all of these, however, it is under perfect control; it is chained, so to speak, by the wires which distribute it from the cell in which it is produced by chemical action, or from the generator which transforms the energy of the steam engine into electromotive force.

In order that the difference between the electricity that flows from a mechanical generator or other artificial source and that which abides in the atmosphere and on the earth's surface may be understood, it is necessary that first principles be considered very briefly.

ORIGIN OF ELECTRICITY.

It has been stated that electricity may be produced by chemical action or by mechanical means, but there are still other means by which a body may be given an electrical charge. Thus, if one rubs his feet over a woolen carpet several times and then touches his finger to the gas fixtures a slight spark will pass to the latter with an audible snap. In this experiment the body through friction with the woolen carpet receives a very light electric charge. The latter is discharged, or dissipated, as soon as the finger touches the gas fixture. This experiment is intended to show the ease with which a body can receive an electric charge.

CONDUCTORS AND NONCONDUCTORS.

Bodies do not all behave alike when an electric charge has been given them; thus some of them immediately conduct it away—in other words, the charge does not permanently reside on the body. To these bodies the name of conductor has been given, hence the term "lightning conductor" means a body that will conduct or lead away a lightning discharge. Other bodies have the quality of retaining an electrical charge for some time or of permitting it to escape very slowly. These are called nonconductors or insulators. A conductor, if supported by a nonconducting body, may also retain an electric charge, but the retention of the charge is due to the fact that the nonconducting support of the body prevents the escape of the charge. The metals are good examples of conducting bodies. Glass and gutta-percha are good examples of nonconductors or insulators. Telegraph lines, it will be remembered, are insulated from the poles by glass insulators. At one time it was thought necessary to insulate lightning rods from buildings by glass or porcelain insulators, but that view is not now generally held.

An electrical charge suddenly falling upon a conductor, say an iron rod, will be safely disposed of, provided the conductor is in connection with the earth. On the other hand, the same charge falling upon a piece of wood, the latter being a bad conductor, will split it into many fragments and possibly develop enough heat, by reason of the resistance offered by the wood, to set the latter on fire. For reasons above given, lightning conductors are made with a view of carrying the electrical charge safely to the earth through the medium of a good metallic conductor.

POSITIVE AND NEGATIVE ELECTRIFICATION.

In nature there are two kinds of electrification, viz, positive and negative; thus a body may be either positively or negatively electrified. The law of electrical attraction and repulsion is generally stated as follows: Bodies electrified in the same manner repel one another; while bodies, one electrified positively the other negatively, attract one another. In the behavior of oppositely electrified bodies when brought near each other lies the key to many interesting facts in electrical science.

A positively charged body, if placed between two others, one having a positive the other a negative charge, will tend to move toward the latter, due, we are told, to the "electrical field" set up by the oppositely charged bodies. By an "electrical field" is meant the region in which work is done to move an electrical charge from one point to another. This work is susceptible of exact measurement; it varies inversely as the square of the distance separating the bodies, and depends also on the material of the nonconductor separating the bodies. The latter is generally called the "medium" or "dielectric;" thus the air separating one cloud from another, or a cloud from the earth, is known and referred to as the "medium" or "dielectric." For the purpose of this paper air will be considered as a nonconductor.

The force exerted in transferring an electric charge from one point to another, as before stated, depends upon the character of the medium through which it is transmitted. If the medium is a conductor, it will pass from one to the other harmlessly, but if the medium should be a nonconductor, such as the atmosphere, work will have to be done. The work done in the last-named case is manifest in lightning strokes by the rending and splitting of the objects struck, as before stated, and in this we find a reason for the rule in the erection of lightning conductors, viz, that the conductor should be continuous—there should be no air gaps in it, because a vast increase in the expenditure of energy on the part of the lightning stroke is necessary to cross the gap of nonconducting air. In this principle is also found an explanation of the fact generally observed in the case of a person struck by lightning, viz, that the shoes are almost always torn from the body and badly wrecked. The air gap between the body and the ground, although very small, is sufficient to produce the observed effect.

A point has now been reached when it is necessary to introduce another technical term, viz, "electrical potential," or simply "potential." The idea conveyed by "potential" is of the same nature as that of difference in level in case of water; thus water always flows from the higher to the lower level, and the force with which it flows depends, among other things, upon the amount of the difference in level. So in electrical terminology a current of electricity flows from a body with a high potential to a body with a lower potential; or, in other words, the distribution of the electric charge on both bodies is very materially changed when they are brought into conducting communication.

In the definition of a lightning flash on a previous page one of the great differences between a lightning flash and the ordinary electric current was not pointed out, viz, the first differs from the second in that it is at a much higher potential; that is, the force or pressure that impels it is tremendously greater than that which, for example, causes an electric current to flow along a trolley line. The latter flows under small pressure through a conductor, while the former breaks down the air, a nonconducting body, throughout a path sometimes more than a mile in length.

To recapitulate: Thus far it has been shown that a body may receive an electric charge in several ways; that there are two kinds of electrification; that different bodies behave differently with respect to holding electrical charges; that there is an attractive force between bodies oppositely electrified, and some of the laws that govern the transmission of an electric charge from one body to another have been pointed out. There is another method by which an uncharged body may be electrified, viz, by bringing it into the field of a charged body. This method is known as the phenomenon of induction. It is of importance in the erection of lightning conductors, as will now be shown.

Let there be any two parallel wires close together. Through one of them, A, pass an electric current. The flow of this current will induce a current in the other wire, B, in a direction opposite to that in A. Telegraph and telephone lines carried on the same poles are operated with great difficulty because of the induced current set up in the telephone wires by the current flowing through the telegraph wires, and certain devices have to be applied to the former in order to overcome the induction effects.

The application of this principle to lightning conductors lies in the fact that a stroke of lightning falling on the lightning rod is liable to set up side flashes in the metal work of the building that may be near to the lightning conductor. The remedy will be found in the concluding part of this paper.

Franklin was the first to point out that an electrical field exists in the atmosphere during thunderstorms. Later investigators have shown that an electrical field is present in the lower atmosphere even in fair weather, such that a positively charged body would be attracted toward the surface of the earth. We are also told that the surface of the earth is always negatively charged, and further that the charges on these two bodies, viz, the lower atmosphere and the earth's surface, though opposite in character, do not permanently neutralize each other, as might be expected. On the contrary there is a tendency in the electrical condition of air and earth to depart from what might be called normal conditions of fair weather and pass into conditions of great strain in the air which separates one cloud from another or from the earth. This condition of great stress is found in thunderstorms; it is relieved by disruptive discharges from cloud to cloud and from cloud to earth. Once equilibrium is established there is a period of quiet, and then another period of increasing electrification followed by thunderstorms.

ELECTRICITY IN THUNDERSTORMS.

This problem has been freely discussed for several centuries; it has been attacked from many view points and much laboratory work has been done in order to produce a discharge that, in a small way, may be comparable to those observed in nature. Still it can not be said that the precise mechanism of a thunderstorm is known. The most recent theory is one put forth by Dr. George C. Simpson.[a] Doctor Simpson has proven by laboratory experiments that when a large drop of water is broken up into smaller drops in the air the water becomes positively and the air negatively charged. In other words, when each drop of water is broken up a certain number of units of free negative ions and a less number of free positive ions are released. (An ion is understood to be any extremely small material particle which carries a charge of electricity.)

He has further shown that every time a drop breaks a separation of electricity takes place, the water receiving a positive charge and the air a corresponding negative charge. The charge which passes to the air is rapidly absorbed by the cloud particles, and in time the cloud itself may become highly charged with negative electricity. The relation of these facts to the development of thunderstorms will now be pointed out. The latter, it may be remembered, occur for the most part on warm, sultry days; the usual preliminary is the formation of a cloud with a flat base whose summits—for it generally has several—are rounded and tower far into the sky. These rounded summits are the tops of ascending currents of warm air whose moisture, condensed by the cold of elevation, forms the white domelike structure of the cloud. The existence of an ascending current is beyond question; just what velocity the ascending air has is yet somewhat conjectural. A velocity of 18 miles an hour, however, is required by the theory under discussion. Lenard has shown that drops having a diameter greater than two-tenths of an inch are unstable when falling through the air and rapidly break into smaller drops; also that all drops having a diameter less than two-tenths of an inch have a final velocity when falling through the air of less than 18 miles an hour. Thus it will be seen that in the ascending air currents of a thunderstorm no water can fall provided the ascensional velocity is 18 miles an hour or greater; for all drops less than two-tenths of an inch in diameter are carried upward, and all drops having a larger diameter quickly break into smaller drops. The above facts, together with his observations and experiments, lead Doctor Simpson to formulate the following theory for the origin of electricity of thunderstorms:

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[a] Proceedings of the Royal Society, series A, vol. 82, p. 169.

> It is exceedingly probable that in all thunderstorms ascending currents greater than 18 miles an hour occur. Such currents are the source of large amounts of water which can not fall through the ascending air. Hence at the top of the current, where the vertical velocity is reduced on account of the lateral motion of the air, there will be an accumulation of water. This water will be in the form of drops which are continually going through the process of growing from small drops into drops large enough to be broken. Every time a drop breaks a separation of electricity takes place, the water receives a positive charge, and the air a corresponding amount of negative ions. The air carries away the negative ions, but leaves the positively charged water behind.
>
> A given mass of water may be broken up many times before it falls, and in consequence may obtain a high positive charge. When this water finally reaches the ground it is recognized as positively charged rain. The ions which travel along with the air are rapidly absorbed by the cloud particles, and in time the cloud itself may become highly charged with negative electricity. Now, within a highly electrified cloud there must be a rapid combination of the water drops, and from it considerable rain will fall; this rain will be negatively charged and under suitable conditions both the charges on the rain and the rate of rainfall will be large.
>
> A rough quantitative analysis shows that the order of magnitude of the electrical separation which accompanies the breaking of a drop is sufficient to account for the electrical effects observed in the most violent thunderstorms. All the results of the observations of the electricity of rain described above are capable of explanation by the theory, which also agrees well with the actual meteorological phenomena observed during thunderstorms.

Whatever may be the origin of the electricity of the air, its effects upon the various terrestrial objects upon which it falls are well known. From its effects we are able to infer that the intensity of the charge in the lightning flash varies between very wide limits. Not every discharge is heavy enough to take life or badly splinter a tree, so that we can at once distinguish between light flashes generally harmless and heavy flashes which splinter trees or kill live stock and human beings. A third class may also be recognized, viz, the violent disruptive discharge, which, as pointed out by Sir Oliver Lodge, is the result of a discharge initiated elsewhere, such, for example, as when one cloud discharges to another cloud between it and the earth. When this happens the free charge on the earth side of the lower cloud will be suddenly relieved and fall upon the earth through previously unstrained air as a discharge of the most violent and explosive type.

When a thunderstorm develops and moves over the land the air between the under surface of the cloud and the earth's surface is able at first to resist the passage of a discharge between cloud and earth, but as the electrification increases the strain in the air becomes too great and a discharge follows. The zone of danger in a thunderstorm is, therefore, generally equal to the area of the cloud itself, sometimes extending a little to the front of the cloud. The heaviest discharges pretty nearly always occur simultaneously with the passage of the storm front. The reason for this can be very easily shown in the laboratory; thus it is well known that if the two poles of a charged electric machine are brought near to each other a spark will pass from one to the other. Now, in order to get the first spark the poles of the electric machine must be brought nearer together than is necessary after several sparks have passed. The passage of several sparks through the air separating the poles evidently electrifies it, and thus it becomes a better conductor.

The area within the storm cloud is what may be called a "danger zone." Within this zone almost any upright object, especially a tree, is a better conductor than the air itself, and is consequently liable to lightning stroke. For this reason to take refuge under a tree is a dangerous proceeding. Other places to avoid are near chimneys or fireplaces and in close proximity to wire fences. The latter, as has been repeatedly stated in agricultural journals and the publications of the Weather Bureau, should be grounded at every fifth post. To successfully ground a wire fence attach to the fence post with staples a piece of galvanized wire, so that some part of this wire will come into actual mechanical contact with the fence wire and extend thence about 2 feet into the ground. A bolt of lightning which may fall upon a wire thus grounded will be quickly carried to the earth and rendered harmless.

The ordinary farm building is not difficult to protect from lightning flashes in the great majority of cases. While absolute protection can not be secured unless the building be incased in a network of wires, it is believed that a building with a properly installed system of lightning conductors will fare better than one without such a system in case a discharge of the most violent type should fall upon it.

Whether or not to install lightning conductors on one's property is a question, after all, of individual judgment. If the property is insured against loss by lightning there would be little incentive toward incurring additional expense for lightning conductors. In case of an isolated farm building standing apart from trees it would seem that the conservative course would be to erect an inexpensive system of lightning conductors, such as will be described in the concluding part of this paper.

LIGHTNING RODS FOR FARM BUILDINGS.

It is proposed to give in what follows instructions which will enable anyone to erect a comparatively inexpensive yet effective lightning conductor, with materials that can be purchased from the larger electric supply houses.

The case of a building on which there is neither cupola nor chimney will be discussed first. Such a building and the method of rodding it is shown in figure 1.

MATERIAL.

The material necessary for the construction shown in figure 1 consists of (a) sufficient length of No. 3 or No. 4 double galvanized-iron telegraph wire, (b) about a pound of galvanized-iron staples, (c) three or four connecting tees, (d) 1 pound of aluminum paint. While iron is not so good a conductor as copper it is less likely to cause dangerous side flashes, and it also dissipates the energy of the lightning flash more effectively than does the copper.

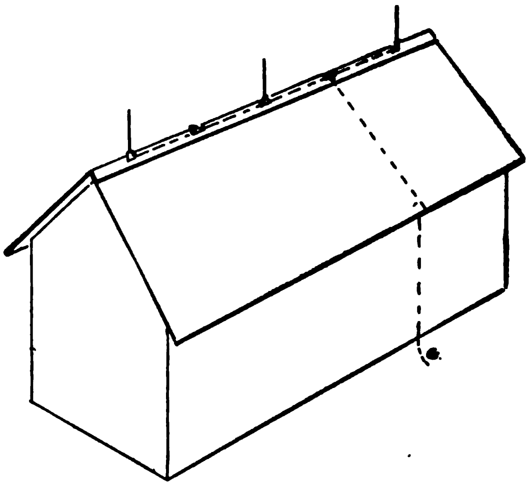

FIG. 1.—Method of placing lightning rods on a building having no cupola or chimney. Length of building, about 25 feet.

The high price of copper cable adds greatly to the price of manufactured lightning rods made out of that metal. An experiment performed by Sir Oliver Lodge before a committee studying the effect of lightning on various conductors bears directly on the utility of copper and iron as lightning conductors. It is here given:

> A thin sheet of metal mounted on nonconducting standards represented the cloud, which was charged at will from a Leyden jar. The "cloud" was so arranged that the model lightning conductors could have their points brought nearer to or farther from its under surface by shifting their positions on the table. Conductors of copper, iron, and wet strings were experimented with. The disruptive discharge to the copper proved to be the loudest and most intense by far of the three. The iron took the flash with less noise, the wet string with hardly any; yet when the discharge passed through it the other and apparently better conductors were not affected. The experiments tended to demonstrate that iron is in many situations a very useful material for lightning rods, as the effective energy of a flash of lightning is rapidly dissipated in iron.

Iron oxidizes rapidly when exposed to the air; it is necessary, therefore, that it be galvanized. In the trade there is both single and double galvanized. Double galvanized or Extra Best Best should be used. There are several gauges in use by wire manufacturers both in this country and abroad. The differences between one gauge and another are not great, yet it should be remembered, for example, that the "B. & S." gauge (Brown & Sharpe) is smaller than either the Roebling (John A. Roebling & Sons) or the Birmingham wire gauge of England. No. 2 wire, B. & S. gauge, measures 0.257 inch in diameter. To get approximately the same diameter in the Roebling or the Birmingham gauge No. 3 wire should be procured. The diameter of the latter is roughly a little over a quarter of an inch.

The size of wire here recommended for lightning conductors (No. 3 or No. 4) is less than that prescribed for main conductors by the English Lightning Research Committee of 1905. The only objection that can be urged against the smaller wire is that of insufficient capacity. Some years ago the opinion was prevalent that the sectional area of an iron conductor should be six times as great as that of a copper conductor. It was also believed that the diameter of a copper conductor should be not less than three-eighths of an inch. Accordingly for a main conductor of iron it would be necessary to erect a rod over 2 inches in diameter. Such a size would nowadays not be considered as either necessary or practicable. The ordinary telegraph wire has a diameter of about fifteen one-hundredths of an inch; it is often struck by lightning, yet it is seldom fused. It is probable that, although a light iron wire may be melted, it will have served its purpose before being destroyed. No. 3 wire is about twice the size of telegraph wire (No. 9). So large a wire is rarely, if ever, used in telegraph circuits, but it comes into use on high-power electric transmission lines. The writer does not know of a case wherein that size has been fused by a lightning discharge, and therefore feels no hesitancy in recommending its use as a lightning conductor for isolated farm buildings of moderately small heights.

There are other forms of soft iron conductors that would serve as lightning rods, particularly the lighter cables, say three-eighths of an inch in diameter. This form of conductor has the advantage over a solid conductor of the same size in that it is more easily handled. It can be bent over the eaves of a building or around an obstacle more readily than the solid wire, and the ends admit of being fuzzed out like a broom. The additional points thus gained serve a useful purpose on the upper ends of the terminals. Soft iron wire cable, double galvanized, is not so easy to obtain as the solid wire, and for that reason preference is given the solid wire.

The T connections are shown in figure 2. They should be galvanized in order to protect them from the corrosive influences of the atmosphere.

When the length of a lightning conductor is increased, as in a building of greater dimensions than shown in figure 1, the increased resistance of the wire is equivalent to a diminution of the sectional area; accordingly a larger size of wire should be used, that is to say, if a No. 4 wire is used on a small building, No. 3 should be used on a larger one.

DIRECTIONS FOR PUTTING UP WIRES.

The conducting system is composed of a horizontal wire following the ridge of the roof and two vertical wires connecting with the ground on both sides of the building.

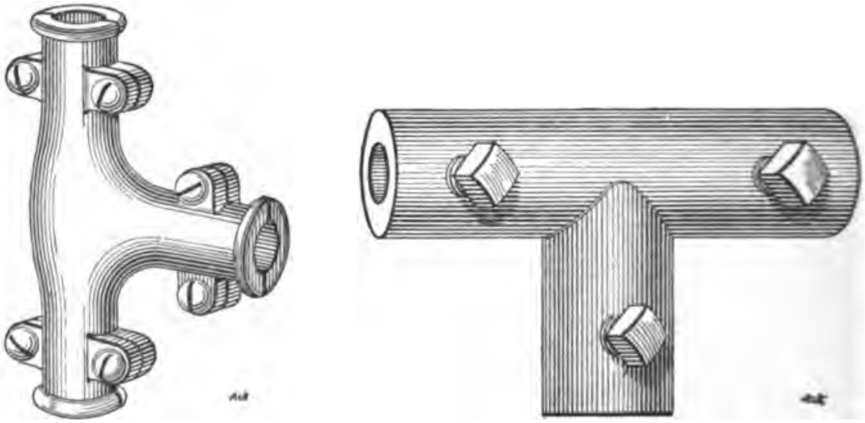

FIG. 2.—Two types of T connections.

The wires should be fastened to the building by galvanized iron staples about an inch long; they are not to be insulated from it as was once the practice. Another way to fasten the wire to the building is by means of small wooden blocks and screw eyes. Blocks 1½ inches thick, 2½ inches wide, and 4 inches long into which a stout screw eye is fastened may be nailed to the sides and roof at intervals of 10 feet or less. The wire can be easily passed through these eyes from the ground to the top of the building.

The vertical wires should be connected to the horizontal wire by galvanized iron tees (fig. 2). The necessary tees should be slipped onto the horizontal wire and placed at points of junction with the downward directed wires, and also at such points as it is wished to erect short terminal rods along the ridge of the roof.

TERMINALS.

Three terminals are shown in figure 1. These rods need not be more than 20 inches long. The end terminals are best formed by making a right angle bend in the wire which runs along the ridge of the roof at a distance of 20 inches from the respective ends. The middle terminal is merely a wire 20 inches in length held in place by a T connector. The terminals are short and offer little resistance to the wind; they are kept in a vertical position by the connections between the ridge wire and the wires leading to the ground.

The end of the upper terminal should not be left blunt, but should be filed down until it is cone shaped. Since the filing removes the galvanizing over the surface of the cone, the latter should be heavily coated with paint to preserve it from rust.

In general a terminal rod should be erected every 18 or 20 feet along the ridge of the roof.

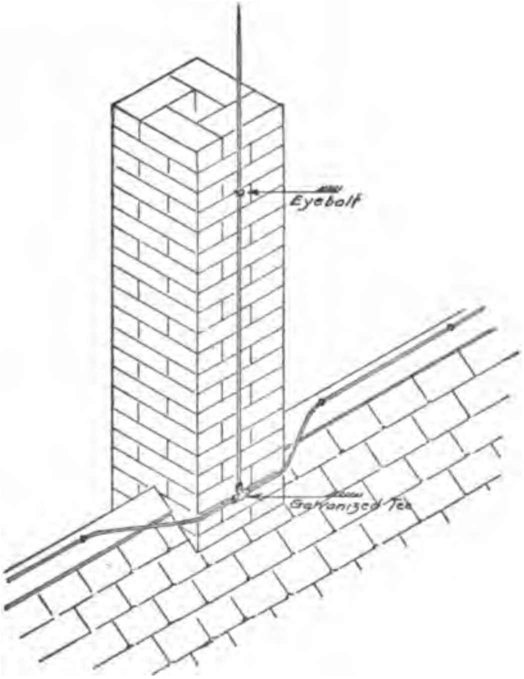

FIG. 3.—Showing method of running horizontal conductor around a chimney or cupola.

The number of terminal wires depends on the number of cupolas, chimneys, or other salient points on the roof liable to be struck. A short terminal wire connected to the main conducting wire by a tee should be erected at each cupola or other salient point. The method of running the horizontal conductor around a chimney or cupola is shown in figure 3.

EARTH CONNECTIONS.

The earth connections require great care in their construction. The essential thing is to reach permanently moist earth in the shortest distance from the main conductors. The building shown in figure 1 has two ground connections, one on each side of the building. Two kinds of ground connections are suggested. The ground ends of the vertical conductors, or wires, should be coiled in a spiral having a diameter of about a foot. These spirals should be buried in moist earth at whatever depth the latter is found. If there are no down rain spouts on the building the ground connection should be placed in the line of the drip from the roof, since the latter has a tendency to keep the earth moist. This construction has the advantage of an unbroken run of wire from the ground to the roof of the building. When the main conductors run from the roof of the building to the base only there is often trouble in making a perfect joint between them and the materials used for ground wires. It is a distinct advantage to have the entire system of one and the same kind of conducting material.

The second suggestion is to take a galvanized water pipe, say an inch and a quarter in diameter, and drive it into the ground at the foot of the main conductors. Secure a cap for the top of the pipe and bore a hole through it so that the conducting wire can be passed through; then insert the wire into the iron pipe, fill the interstices with powdered charcoal, and place the cap on the pipe. The hole in the cap should be large enough to permit the conducting wire to pass easily through and at the same time allow water to pass down the wire into the interior of the pipe.

The number of ground connections in the simple case considered in figure 1 is but two, one on each side of the building. When the size of the building is increased, more vertical wires will be needed and consequently more ground connections. The number of such connections, therefore, will depend on the number of vertical conductors. In general, it is advisable to run a vertical conductor up the side of a building for each 25 or 30 feet of its length; thus, for example, a barn 56 feet long should be equipped with at least two vertical conductors on opposite sides of the building.

BUILDINGS WITH METALLIC ROOFS.

A metallic roof properly connected to the earth affords a reasonably good protection to the building from lightning. In suburban districts where frame buildings with tin roofs prevail there is little destruction by lightning; most of the buildings have down rain spouts, which serve to conduct the discharge to the earth. In the case of an isolated building with a tin roof care should be taken to see that the down rain spouts are connected with the ground. It will not do to stop them within a few inches of the ground; there should be an unbroken metallic path from the ridge of the roof into the ground.

In providing a ground wire to connect the lower end of a rain spout with moist earth, a wire such as hereinbefore described, a wire cable, or a piece of galvanized pipe may be used. The vital points of the connection are two; first, to reach permanently moist earth and, second, to secure a perfect metallic joint between the down spout and the earth conductor. If a wire is used it should be flattened out at the end in the form of a tape and then bolted and soldered to the rain spout. This form of a joint is not very durable, since the tin is apt to oxidize unless it is kept well painted.

In the case of a building with a metal roof, but no down spouts, it is desirable, in order to obtain protection from lightning, to run a wire conductor from each of the four corners of the roof to the earth. The precautions described in the preceding paragraph as to making good metallic joints should be observed.

The foregoing is applicable to the simplest form of construction. As the size of the building to be wired increases, the difficulties in wiring also increase somewhat. The longer the total run of the wire the greater becomes the electric resistance; to offset this the sectional area, or the diameter of the wire, should be increased, as before stated.

In determining the size of the wire to be used the following may be helpful: If the building is small, such as shown in figure 1, a short run of wire will answer, viz, up one of the longer sides of the building, along the ridge of the roof, and down the other side. In this case use No. 4 wire. The size of the wire diminishes as the numbers increase. Thus a No. 3 wire is larger than a No. 4, their respective diameters (B. & S. gauge) being as follows: No. 3, 0.244 inch; No. 4, 0.225 inch. If the building is large enough to require two vertical wires on each side of the building and a wire along the ridge of the roof, it would be advisable to use No. 3 wire.

All objects on a building higher than the ridge of the roof should be protected by short terminal wires, and the latter should be joined to the main conductor provided the distance is not over 10 or 15 feet. If the distance is greater it would be better to run a conductor direct to the ground, the usual precautions as to reaching permanently moist earth being observed.

The form of wiring when passing a chimney or a cupola is shown in figure 3. It will be noticed that the bend in the wire is gradual, not abrupt. The terminal wire for the chimney should be erected at the point shown in the drawing. Likewise in passing over the eaves of a building a goose-neck bend is preferred to a sharp one.

If the overhang of the roof is excessive, a hole should be bored through it to let the wire pass close to the wall of the building.

The following-named points not specifically mentioned in the text should be observed:

(1) If there are gas pipes in the building keep the lightning conductors away from them as far as possible. On the contrary, large masses of metal, such as water pipes, should be connected to the

conductors. The water pipes should be in good connection with the ground.

(2) Joints should be held together mechanically and should be frequently examined to see that they are not broken.

PAINTING.

The whole system should receive two coats of aluminum paint; it should be repainted every few years.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 368.

THE ERADICATION OF BINDWEED, OR WILD MORNING-GLORY.

BY

H. R. COX,

Scientific Assistant, Office of Farm Management,
Bureau of Plant Industry.

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1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 14, 1909.

SIR: I have the honor to transmit herewith a manuscript entitled "The Eradication of Bindweed, or Wild Morning-Glory," by Mr. H. R. Cox, Scientific Assistant in the Office of Farm Management, and recommend that it be published as a Farmers' Bulletin.

Several species of perennial bindweed have more or less weedy tendencies and in some sections of the country they constitute the most serious weed pest with which the farmer has to contend. Mr. Cox has made a careful study of these species, giving special attention to their root habits, and has found three practicable methods, which are given in the manuscript, by which these weeds may be exterminated.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction.. 5
Injurious effects of bindweed.................................. 5
Distribution.. 7
Description... 8
  Characters of the weed above ground........................... 8
  Underground characters of the weed............................ 9
Methods of eradication.. 10
  Clean cultivation... 11
  Growing alfalfa hay... 14
  Pasturing with hogs... 14
  Other methods of eradication.................................. 17
    Pasturing with sheep.. 17
    Use of smothering crops..................................... 17
    Use of artificial smothering material....................... 17
    Use of chemicals.. 18
Summary... 18

ILLUSTRATIONS.

Page.
FIG. 1. Rootstocks of bindweed growing shallowly in a clay soil of medium depth.......... 8
2. Branch with flowers of hedge bindweed (*Convolvulus sepium*).......... 9
3. Branch with flowers of field bindweed (*Convolvulus arvensis*).......... 10
4. Underground parts of hedge bindweed.......... 11
5. A weed cutter with a V-shaped knife and with a downward-pointing beak at the angle of the knife.......... 12
6. A second type of weed cutter that has proved satisfactory in exterminating bindweed.......... 13

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THE ERADICATION OF BINDWEED, OR WILD MORNING-GLORY.

INTRODUCTION.

The terms "bindweed" and "wild morning-glory" are rather indiscriminately applied to the various species of the genus of plants known by botanists as Convolvulus that are of importance as weeds. In certain limited sections other common names are used to refer to these species, such as gopher vine, pea vine, and wild sweet potato. By far the larger number of these plants are classified under the two species *Convolvulus sepium* and *C. arvensis*, the former a native of this country and the latter an introduction from Europe. There are a few other species, principally *Convolvulus sepium repens* and *C. californicus*, that occur as weeds in certain regions. The former is a variety of *Convolvulus sepium*, but is often referred to as *C. repens*.

In many parts of the country these species rank among the worst of all the weeds that trouble the farmer, and in some regions they are by far the worst. Being perennials, they propagate not only by their seeds, but also by their underground parts. It is the latter character especially that makes them such formidable enemies to the tiller of the soil. The common or cultivated morning-glory, with the large bell-shaped flowers of various colors, is sometimes found in fields where it has escaped from cultivation. This is an annual not difficult to control and should not be mistaken for a species of Convolvulus.

INJURIOUS EFFECTS OF BINDWEED.

For convenience in considering the injury caused by bindweed, the various types of farming may be divided into four general groups: (1) The growing of cultivated crops, which includes truck, small fruits, and commercial seeds; (2) small-grain growing; (3) orcharding and vineyarding; and (4) hay growing.

(1) It is in the first group that the wild morning-glory, or bindweed, gives the most trouble. It not only contends with the crops mentioned for the moisture and fertility of the soil, but climbs and twines around them, dragging them to the ground. Unless thorough and frequent cultivation is given from the first the bindweed will get such a start that subsequent tillage will drag down much of the top growth of the crop. Some crops will grow better than others in a bindweed field. Corn, for instance, if it secures a good start, will make a fairly good growth in spite of the weed. But such low-growing crops as potatoes, strawberries, and onions are overpowered and smothered unless most persistent cultivation and expensive hand hoeing are pursued.

It is impossible to eradicate this weed in cultivated crops with the implements commonly used, as many of the stems slip through the teeth or shovels without being much disturbed. In fact, anything short of good cultivation is a benefit to the bindweed, since insufficient cultivation merely breaks it up and distributes it over the field. After the crop is laid by, the weed grows undisturbed and often becomes a dense mat of vines on land that had been given fairly good cultivation earlier in the season. In many cases this weed has caused a discontinuance of this type of farming.

(2) As a rule, bindweed does not do much damage to small grain. There are, however, regions especially favorable to the growth of this weed where these crops are greatly injured. Besides robbing the soil of moisture, this weed binds and drags down the tops; it also makes harvesting difficult by clogging the knife of the binder.

The time of sowing has much to do with the amount of growth made by the weed. If grain is sown in the fall or early spring it will have made a fair growth before the wild morning-glory gets under way. The height of the stand is also a factor, as a tall growth will produce a greater shading effect than a short one. In western Kansas, where a low-stemmed type of wheat is grown, the bindweed has worked in badly, there being entire quarter sections which are thickly set with it. In those localities, however, where small grain occurs in a short rotation with well-cultivated corn and clover the weed does not do much damage to the grain.

(3) In orchard and vineyard lands, and this applies especially to those of the West, the wild morning-glory is of still less consequence. The use of the weed cutter or weed knife in orchard cultivation, as is the common practice in California, has greatly lessened the weed problem. Furthermore, the shading effect of the trees does much to keep the weed under control.

Those ranchers who give normal cultivation to their orchards do not worry much about this weed. To a certain extent they consider it an advantage, since it springs up after cultivation stops and makes a good winter cover crop. But in cases where orchards receive insufficient cultivation the weed is a more or less serious injury to the trees, especially to young trees. Bindweed is a greater nuisance in vineyards than in orchards on account of the lack of shade and the greater difficulty in the use of the weed knife.

(4) The presence of wild morning-glory vines, although it injures the market value of hay, probably does not materially affect its feeding value. In the case of alfalfa, clover, cowpeas, and other hay crops that produce a shading effect, the bindweed is a negligible factor.

DISTRIBUTION.

Bindweed is found in most sections of the United States and southern Canada. Although it sometimes occurs on upland soils, it is found more often on deep bottom lands and on rich prairie soils. The weed is therefore at its worst on the most productive and most valuable land. It grows on the valley lands of New England, the Middle Atlantic States, and to a lesser extent in the Southern States; also, in the entire area of the Corn Belt and on the valley lands of the West. East of the one hundredth meridian the native hedge bindweed is the most common species, although the field bindweed is also widely scattered. West of that point the field bindweed is probably the most common species, the hedge bindweed occurring to some extent in California. The trailing form with downy leaves (*Convolvulus sepium repens*) has been reported as a weed from central-western Kansas only, in which locality it has become a most serious menace to the wheat growers. The fourth species of importance as a weed is the California form (*Convolvulus californicus*), which occurs only in central-western California, for the most part on hill lands.

Although bindweed usually occurs distributed generally over the land, it is sometimes confined to well-defined patches. It is not an uncommon sight to see one or more of these patches in a field, each of a more or less circular outline, indicating that the weed is spreading by its underground growth from a central point of infection. Where the land has been infested for some time and careless cultivation has been given, the weed becomes scattered over the land.

Another interesting point which has been disclosed by a study of this weed under field conditions is that the underground parts rarely penetrate the subsoil. This depends, however, somewhat on its character, since a subsoil that resembles the surface soil in texture and fertility admits the roots and rootstocks to a certain extent. In all cases where the subsoil is of an impervious or clayey nature the underground parts of the plant are confined to the soil stratum entirely. Figure 1 represents the rootstocks going no deeper than 6 inches in a clay soil of medium depth on the Arlington Experimental Farm of the Department of Agriculture. The bottom of the drawing marks approximately the subsoil line.

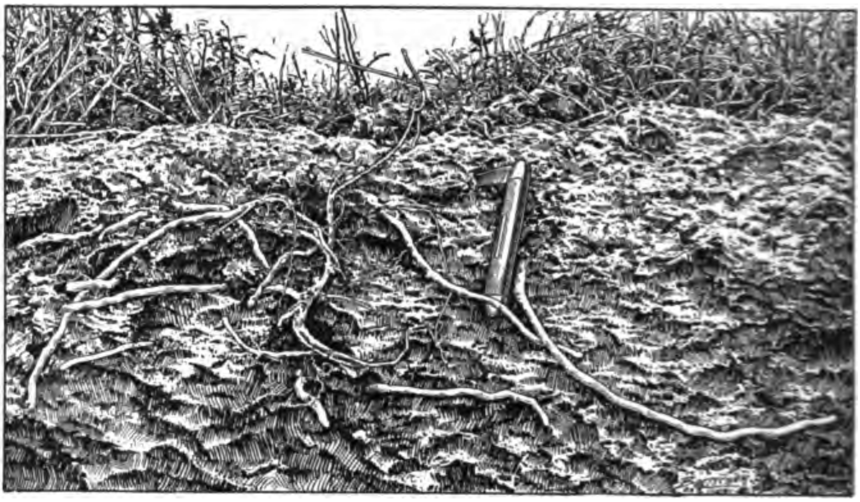

FIG. 1.—Rootstocks of bindweed growing shallowly in a clay soil of medium depth.

DESCRIPTION.

CHARACTERS OF THE WEED ABOVE GROUND.

Convolvulus sepium L. (fig. 2) has a long, twining stem, with triangular, halberd-shaped leaves, that is, arrow shaped, with the basal lobes pointing outward. The flowers are funnelform, with much the same appearance as those of the cultivated morning-glory, but are always white or rose colored. The base of the flower is inclosed in bracts about three-fourths inch in length. The most widely accepted common name for this plant is "hedge bindweed."

The stem of *Convolvulus arvensis* L. (fig. 3) is either trailing or twining and the leaves are somewhat egg shaped, with the lobes at the bases pointed and projecting. The flowers are funnelform, white or tinged with red, but are not nearly as large as those of *Convolvulus sepium*. The bracts surrounding the base of the flowers are small. The common name of widest acceptation is "field bindweed."

Convolvulus sepium repens Gray is much like the hedge bindweed except that the stem and leaves are more or less downy, and the stems are trailing rather than twining.

The California form of bindweed (*Convolvulus californicus* Choisy) has stems from 1 to 15 inches in length. When short they are erect; when long, trailing. The leaves vary from oval to triangular in outline and are about an inch long. The bracts are of medium size and the flowers are of about the same size and shape as those of the hedge bindweed, white or creamy, with purplish exterior.

UNDERGROUND CHARACTERS OF THE WEED.

A study of the eradication of any perennial weed should begin with a consideration of its underground parts. When the character of its underground growth is determined the next step is to devise a method of eradication based on its habits. The underground parts of the various species of Convolvulus are divided into two groups, which are illustrated by the hedge bindweed on the one hand and by the field variety on the other.

The hedge bindweed may start growth in the spring from near the top of the rootstock sent to the surface during the preceding year, or the top growth may come from any part of the preceding year's underground growth. This underground stem forms buds, from which new rootstocks grow. Furthermore, new rootstocks may grow from any of the buds along the old rootstock. Figure 4 shows new rootstocks put forth from both the new underground stem or shoot and the old rootstock. This fact indicates that an individual rootstock or piece of a rootstock may retain its vitality for two or more years if left undisturbed.

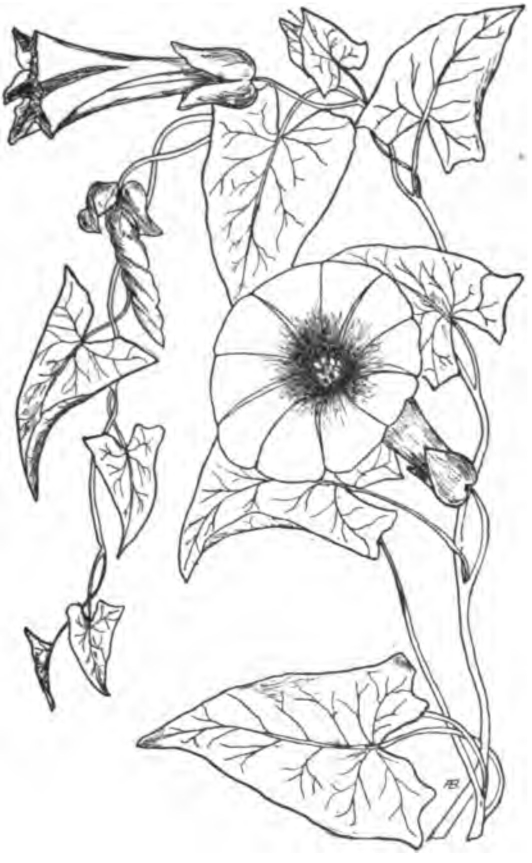

FIG. 2.—Branch with flowers of hedge bindweed (*Convolvulus sepium*).

The field bindweed is propagated by roots instead of rootstocks. These roots extend in a more or less horizontal direction from several inches to several feet below the surface. At any point along the root an adventitious bud may form, from which a branch root grows or a root shoot is sent to the surface. These root shoots form buds, from which other root shoots grow to the surface, thus giving the impression that the plant propagates by rootstocks.

METHODS OF ERADICATION.

From the facts stated it is evident that the only successful methods for the eradication of bindweed must be based on the suppression of all top growth, in order to starve out the underground parts, except, of course, those methods, at present of little value, which have for their object the direct killing of the roots or rootstocks by the application of chemicals. A great many farmers are looking for some easy method of killing the bindweed, and in the mean time are letting it cover the fields and festoon the trees of the orchard. They are looking for some magic "remedy" that will completely eradicate the weed with a small amount of exertion on their part. It must be understood that such a formidable enemy as this weed requires heroic treatment. Other farmers have gone at the problem heedlessly, as in the case of a man who followed the root of a plant to the depth of 4 feet and then applied a large quantity of salt in the hole.

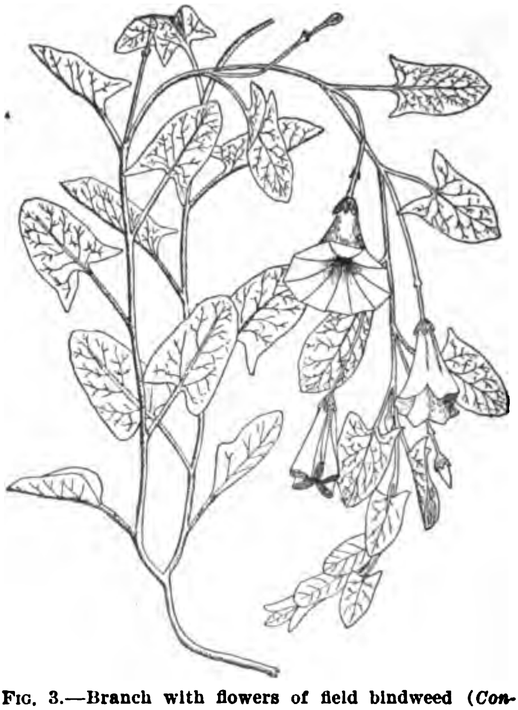

FIG. 3.—Branch with flowers of field bindweed (*Convolvulus arvensis*).

Various methods have been tried to keep down the top growth, and hence starve out the underground parts. There are three methods that have given satisfactory results, namely, clean cultivation, alfalfa growing, and hog pasturing. There are other methods that have been tried, but not with a large measure of success. These include the placing of building paper, beet pulp, apple pomace, straw, or manure on the ground to smother the weed growth, and also the application of chemicals. Conditions in irrigated regions are complicated by the fact that bindweed is often allowed to grow along irrigation ditches, the water in which distributes the seed. The water of streams, especially at flood times, is also a factor in distributing the seeds and roots to other land.

CLEAN CULTIVATION.

Bindweed can be eradicated by clean cultivation if thorough and persistent. The case requires going over the land once every week or ten days during the entire growing season of the weed, which is between the spring and fall frosts. Two years of this treatment will accomplish the result in most cases, and it is probable that one year will suffice where the plant does not root deeply. The difficulty is that many farmers will not cultivate as thoroughly as is necessary. Even a small top growth is enough to form some new underground growth and rejuvenate the old roots or rootstocks, thereby carrying the plant over to the next season. Cultivation has the further advantage of inducing a rapid germination of all seeds of the weed which are in the soil, the young seedlings being promptly destroyed by the subsequent tillage.

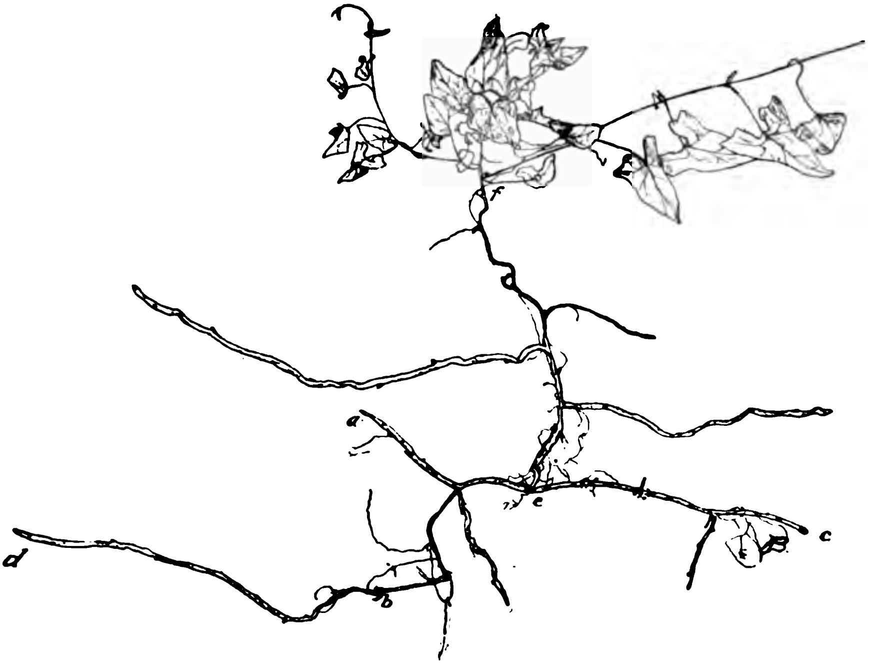

FIG. 4.—Underground parts of hedge bindweed. The piece of rootstock *a*, *b*, *c*, is of a preceding year's growth. The stem *e*, *f*, together with the rootstocks from it and the section *b*, *d*, are of the present season's growth. Drawing made from photograph taken in October.

Conditions in orchard lands are such as to offer a favorable opportunity to get rid of this weed or at least to so reduce it that it does not do much damage. Many California orchardists use a type of implement that has been found to be very successful in the control of weeds—the weed knife. This is made in various patterns, the principal feature being a knife which is run under the surface of the soil at a depth of from 3 to 6 inches, thereby cutting off the tops of all weeds. Fortunately, the underground parts of the bindweed are quite fragile, and hence this implement does very effective work against this weed. Most of these weed knives are attached to a rig somewhat similar to the 2-horse corn worker. The knives are of two different kinds for the most part, the straight blade and the V-shaped blade. The latter seems to be the most satisfactory, since in soils in which a sod or a cover crop has been plowed under the straight blade is apt to clog. These knives make cuts of different widths, varying from 3 to 6 feet. In soils that are cloddy or of a rather stiff nature it is necessary to attach a sharp beak, pointing downward, at the angle of the V, so that the knife will not be forced upward. Figure 5 shows such an implement which has proved quite satisfactory.

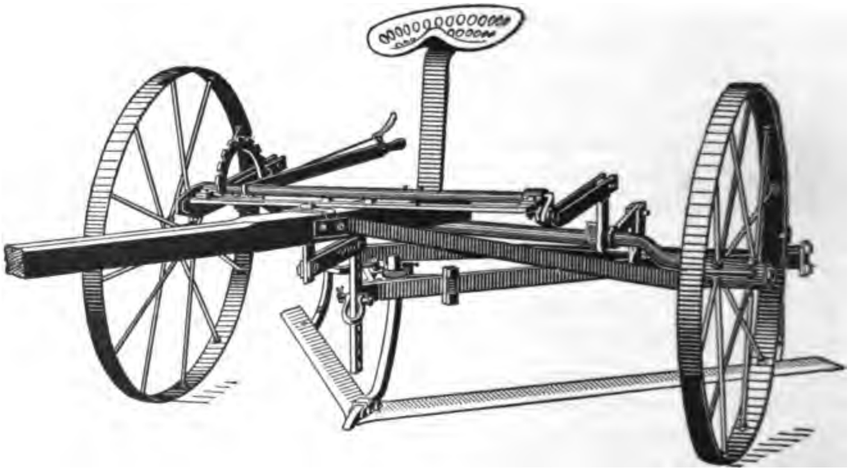

FIG. 5.—A weed cutter with a V-shaped knife and with a downward-pointing beak at the angle of the knife.

Another implement, shown in figure 6, is beginning to be used. It consists of a beam resting on the ground, varying in width from 8 to 12 feet, with a series of knives below, all inclined inward. Its draft is light, it makes a wide cut, it can be worked close to the trees, and is comparatively inexpensive. It is rather difficult to use, however, in cloddy soils.

It is possible, of course, to eradicate the bindweed in bare fallow land by the use of the implements mentioned or the disk if the farmer is willing to do this for a year or more without any return. It is also practicable to give sufficient cultivation with an intertilled crop to get rid of the weed. It is necessary in that case to supplement the cultivator with the hoe after the crop is laid by. This is rather tedious, but it would pay in many cases. Such implements as the "heel" scrape of the South or the "gopher" cutter of the Corn Belt are the best to use in the cultivation of the crop. These perform about the same function as the weed knife in cutting off the tops of the weeds.

As a variation of this plan it might be best to fallow during the first part of the season, using an implement that would keep down the top growth of the bindweed; then in July or August to plant a late intertilled crop, such as rape, sorghum, or Kafir corn. This would carry the cultivation until late in the season. If rape were planted and hogs turned on after laying by they would do much toward killing the weed. The bindweed ceases to grow after frost.

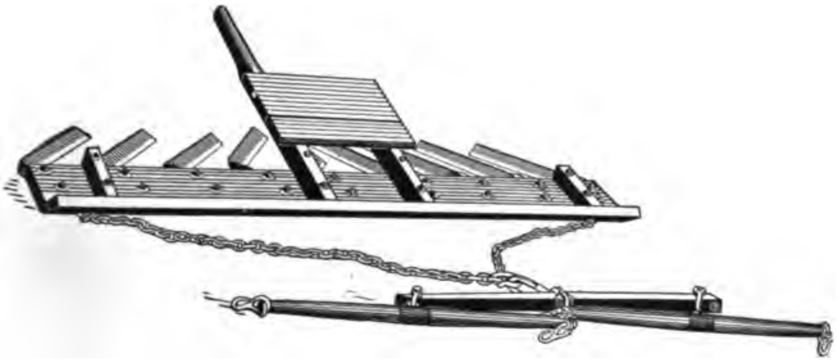

FIG. 6.—A second type of weed cutter that has proved satisfactory in exterminating bindweed.

Another plan that has been successfully employed in California is to alternate fallow with a smothering crop. Such a crop is sown in the fall or early winter, so that by the time the weed begins its growth in the spring the crop has made enough headway to shade the land and exert a smothering effect on the weed. As soon as the crop is off in early summer the land is plowed and fallowed the rest of the season. A repetition of this plan for several years will greatly reduce the weed growth, although no cases have been found in which it has been entirely eradicated. Such crops as peas or horse beans are adapted to this scheme, and in the seed-growing districts sweet peas or mustard.

It is important to note that where the bindweed occurs in patches these should be marked off and given special attention. It is much cheaper to cultivate thoroughly a part of the field than the whole field. Clean cultivation is the most available method of eradicating the bindweed in many cases, and if entered into with a full knowledge of conditions it can be done with less labor and expense than is commonly supposed.

GROWING ALFALFA HAY.

Numerous cases have been found in which bindweed was greatly lessened or entirely eliminated by seeding an infested field to alfalfa for hay. This is effected by two factors, namely, the frequent cutting and the smothering effect of the crop. The frequent cutting serves about the same purpose as clean cultivation in keeping down the top growth of the weed and hence starving the underground parts. After each cutting alfalfa makes a rapid growth, more rapid than the weed, which is thereby shaded. After the first year of alfalfa, bindweed is usually found to be making only a small growth, with stems but a few inches long and leaves of miniature proportions. This method is most effective where the cuttings are made as frequently as possible and where a thick, vigorous stand of alfalfa is secured. An interesting case was brought to notice in the Muskingum bottom land near Marietta, Ohio. Two adjoining fields, both thickly set with bindweed, were seeded the same season, one to timothy and the other to alfalfa. After several years both fields were plowed and the whole planted to corn. It was very apparent where the alfalfa had been by the absence of bindweed, while the other piece of land still contained the weed.

Alfalfa growing as a method of bindweed eradication is applicable, of course, only where it is possible and desirable to grow alfalfa. But where conditions are favorable there is little doubt that two or three years of alfalfa will greatly reduce or sometimes entirely destroy the weed in the most thickly infested fields. By following this crop with a cultivated crop and carefully keeping down the weed growth that still persists the land can be finally cleaned.

PASTURING WITH HOGS.

Hog pasturing as a method of eradicating bindweed is based on the fact that hogs are very fond of the roots and rootstocks of this plant, which taste much like the sweet potato. Hence, if hogs do not have their noses rung or slit they will root to a considerable depth to obtain the underground parts. It is common to see hog pastures which have contained bindweed with the surfaces torn up and rough, showing where the hogs have been at work, even though there is an abundance of forage for them. It is the universal testimony of the best farmers that pasturing with hogs will reduce the prevalence of the weed, although but few have given the plan a thorough trial. This method can be employed in two ways: (1) By turning the hogs on ordinary pasture and (2) by plowing the land and then turning on the hogs.

The first way probably requires a longer time to accomplish the result than the second. Hogs not only eat the tops closely, but they also root for the underground parts in pasture land. Mr. George Wiggins, of Lodge, Ill., has practiced this method for a number of years with success. He leaves the land in pasture for about three years, with a sufficient number of hogs on it to keep it closely pastured. In the summer of 1908 he showed the writer a field of corn which had been in corn and oats for the past three years, previous to which it had been in hog pasture for three years. Before the pasturing began it was full of bindweed, but there is none to be seen now. This field contains 30 acres and carried about 100 hogs, most of them of the spring brood. Adjoining this field was another field of corn, which had been in hog pasture the preceding three years. Before pasturing there had been a great deal of bindweed in this field, but there is none at present. Another field of 14 acres in clover pasture for the first year was being run with 60 hogs. There was bindweed scattered all over it, but it was making a poor growth and was being rooted out. In breaking a pasture Mr. Wiggins plows in the fall, leaving the hogs to root for all they can get in the plowed land. In the spring he plows again and plants corn. He does not ring his hogs, of course. Many other farmers have noticed that running hogs on grass pasture greatly diminishes the quantity of the weed.

With the second plan, the land is first plowed. This accomplishes several purposes; it loosens the soil so that hogs can root more easily; it turns under all other vegetation, thereby limiting the hogs to the bindweed only; and it turns many of the roots and rootstocks to the surface, where the hogs can see them and get them to better advantage. It is often best to plow the infested land more than once during the season. Only a small quantity of feed should be given the hogs in order that they may be forced to devote their attention to the bindweed. Although hogs may not make quite as good gains on this diet as on others, many farmers have reported that their hogs have done very well under such treatment. It is a good plan to have more hogs than are necessary to keep down the bindweed growth and to move them to other pastures at times.

A typical case of the employment of this method of eradication is that of Mr. Price N. Jones, of Towanda, Ill. Mr. Jones had a small patch of about a quarter of an acre of blackberries in which the bindweed became so thick that the bushes ceased to make much growth. He cut them down in September and plowed the land soon afterwards. The fence was then opened to admit some 15 hogs from an adjoining grass lot of 3 acres. The hogs were not on a full feed of corn and at once began rooting vigorously at the bindweed. During the fall, winter, and spring they rooted the field over thoroughly, and practically no bindweed has come up since.

The use of this method means that the land must be given up to this treatment for at least a year. Just how long it requires to completely eradicate the weed it is difficult to say, since it depends upon conditions, especially on how deep the underground parts go. Where the weed does not root deeply, a year is probably enough. Where it does root deeply, two years might be required. It is best to put the land to a cultivated crop following hog pasturing in order to kill the scattering growth that may persist.

As a suggestion, this method of hog pasturing might be used for short periods in a regular rotation without interfering in any way with the rotation. For instance, Mr. Jones turned hogs on oats stubble one summer, the field being seeded to clover, the hogs being kept on during the fall and winter and rooting up the soil a good deal, but not enough to damage the clover seriously. He plowed this field the following fall and put the hogs on again till spring, and then planted corn. He states that the bindweed is very materially reduced.

There are certain features about hog pasturing that limit its use as a means of weed control. The water supply is one of them. It is, of course, much more convenient to have water in the field than to transport it. Most farmers have their hog lots close to the farm buildings, which is more convenient than having them at a distance. Again, it is necessary to make the fences "hog tight," if they are not already so, which involves labor and expense. This, however, may be done cheaply by putting up a temporary hog fence, which, after the hogs are taken off, is to be removed and used again. It is therefore difficult to say whether or not a particular farmer should use hog pasturing as a means of exterminating the bindweed. If it fits into his scheme of farming and the difficulties are not too great, it would be well to employ it. Each case is a problem in itself. Where the conditions are favorable hogs are likely to prove a most effective means of getting rid of this weed.

OTHER METHODS OF ERADICATION.

Pasturing with sheep.—Pasturing with sheep has been reported to have killed the bindweed, but the evidence on this point is meager. It is possible that if a grass pasture is run with a sufficient number of sheep for a long enough time the weed will disappear. Grass can stand close pasturing better than most weeds, if they are grazed equally close, but it remains to be demonstrated whether or not this plan will completely eradicate the bindweed, and, if so, how many years it will require. In parts of the far West, where grass becomes brown and dry during the summer season, sheep are reported to have killed the weed, for the reason that it is often the only vegetation that remains green in the pasture at that season. There is no doubt, however, that sheep are of assistance to hogs in pasturing for the eradication of bindweed. They eat the tops close to the ground, which checks the growth of the weed.

Use of smothering crops.—By smothering crops are meant those crops, other than alfalfa, that exert a shading effect on weed growth, such as cowpeas, soy beans, millet, sorghum, and buckwheat. No extensive trials of these crops as a means of controlling the bindweed have been made, so it is impossible to define at the present time their adaptability for this purpose. With a continuous succession of such crops, and when thick stands are secured, it is probable that in time the weeds would be much reduced. At best, however, these crops are hardly as effective as alfalfa.

Use of artificial smothering material.—Building paper, manure, beet pulp, apple pomace, straw, and other litter have been much used in the attempt to smother out bindweed growing in patches. It is necessary to apply such material, except building paper, quite thickly on the ground to prevent the weed from pushing through, as it has been known to go through a thickness of 2 feet. This method is therefore rather expensive and is not applicable to any but small areas. Indeed in most cases it is misdirected energy, which could be employed more profitably in some other direction. The use of building paper has been tried with some success on small areas where the laps were carefully weighted down with soil to exclude all light. Such paper can be purchased at from $2.25 to $4 per 1,000 square feet, depending on the thickness of the ply, which is at the rate of $97 to $172 per acre. This cost makes the method impracticable except for very small areas. The thin ply would be about as satisfactory as the thick. If the bindweed were inclined to grow through at the laps it would be necessary to lay another thickness of the paper, the laps running at an angle to those underneath. The paper would probably have to be renewed each season, and it would take as long to subdue the weed as it would by means of clean cultivation.

Use of chemicals.—Many farmers have applied salt, kerosene, lime, and other substances for the purpose of killing the underground parts of the bindweed. One difficulty with this method is that on account of the habits of the roots and rootstocks of bindweed such applications must be spread all over the infested area, which makes the cost so high that these materials can be used profitably in only a limited number of cases. Another difficulty is that a quantity sufficient to kill the weeds will also injure the land to such an extent that no crops can be grown for several years subsequently. Crude salt is probably the cheapest material for the purpose.

Tests have been made by agricultural experiment stations and farmers to kill bindweed by repeated applications of salt, iron sulphate, arsenite of soda, and other chemicals in solution as sprays. Such experiments have failed to show that this method is of any value. Although the tops are killed to the ground new plants immediately spring up. The sprayings must be given once every few days during the growing season for at least two years before the weed finally ceases to grow. The result can undoubtedly be accomplished in less time and with less expense by some other method.

SUMMARY.

(1) The names bindweed and wild morning-glory refer to the several species of the genus of plants known as Convolvulus that are considered weeds, including primarily hedge bindweed (*Convolvulus sepium*) and field bindweed (*C. arvensis*), two other species, *Convolvulus sepium repens* and *C. californicus*, being of secondary importance.

(2) These weeds are a very serious detriment to the growing of crops in many regions. They are especially important in cultivated crops, are sometimes of a serious nature in small grain and orchards, but do no serious damage to forage crops.

(3) Bindweed usually occurs on bottom lands and rich prairie soils. It is sometimes found growing in patches, but it is more common to find it distributed more or less generally over the field. Its depth of rooting is governed largely by the nature of the soil.

(4) The underground parts are of two forms, exemplified by hedge bindweed and field bindweed; the first is propagated by rootstocks and the second by roots. The nature of the underground parts of both of these forms indicates that the top growth must be kept down, thereby starving out the roots and rootstocks, in order to eradicate the weed.

(5) Several methods for accomplishing this eradication have been successful. Clean cultivation is one of the best in many cases. It is essential to employ such implements as will keep down the top growth successfully. Where the weed occurs in patches these should be marked off and given special attention.

(6) The bindweed may be greatly reduced or entirely destroyed by seeding the land to alfalfa. The frequent cutting and the shading effect of this crop are the determining factors. Alfalfa should be followed by a cultivated crop to complete the work of destruction.

(7) Pasturing with hogs has been successful in killing bindweed, since hogs are quite fond of the underground parts. This method can be used with both ordinary pasture and fallow land. Results can probably be obtained in less time in the latter case.

(8) Several other methods have been tried, but they are for the most part of doubtful value. The use of chemicals has not been attended with much success in the control of this weed.

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FARMERS' BULLETIN 369.

HOW TO DESTROY RATS.

BY

DAVID E. LANTZ,
Assistant, Bureau of Biological Survey.

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., June 25, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a report by David E. Lantz, an assistant in the Biological Survey, on How to Destroy Rats. It is in the main a digest of Bulletin 33 of this bureau, now out of print, and is intended to meet the numerous requests from all parts of the country for practical directions for ridding communities of these destructive rodents. If the importance of rat-proof construction in building and the necessity of depriving rats of food were generally understood, the measures adopted for their destruction would be far more successful.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
Means of repressing rats 6
  Rat-proof building 6
  Keeping food from rats 8
  Natural enemies of rats 9
  Destruction of rats 10
    Traps 10
    Poisons 14
    Domestic animals 16
    Fumigation 17
    Micro-organisms 18
    Organized efforts to destroy rats 18
Summary of recommendations 19

ILLUSTRATIONS.

Page.
Fig. 1. Brown rat 5
2. Method of baiting guillotine trap 10
3. Rat caught in unbaited guillotine trap 11
4. Barrel traps 13
5. Pit trap 13

HOW TO DESTROY RATS.

INTRODUCTION.

The brown or Norway rat (*Mus norvegicus*) is the worst mammal pest in the United States, the losses from its depredations amounting to many millions of dollars yearly—to more, probably, than the losses from all other injurious mammals combined.[a] In addition to its destructive habits, this rat is now known to be an active agent in disseminating infectious diseases, a fact which renders measures for its destruction doubly important.

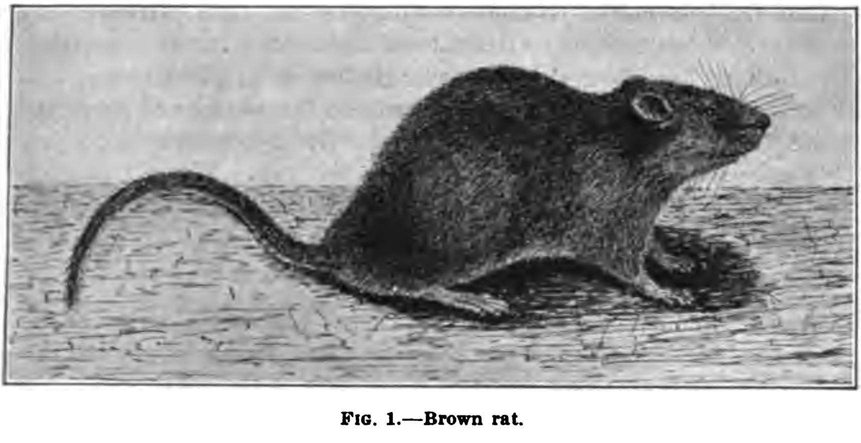

FIG. 1.—Brown rat.

Introduced into America about 1775, the brown rat has supplanted and nearly exterminated its less robust relative, the black rat, and despite the incessant warfare of man has extended its range and steadily increased in numbers. Its dominance is due to its great fecundity and its ability to adapt itself to all sorts of conditions. It breeds three, four, or even more, times a year, and produces from 6 to 17 young in a litter. Females breed when only 4 or 5 months old. The species is practically omnivorous, feeding upon all kinds of animal and vegetable matter. It makes its home in the open field, the hedge row, and the river bank, as well as in stone walls, piers, and all kinds of buildings. It destroys grains when newly planted, while growing, and in the shock, stack, mow, crib, granary, mill, elevator, or ship's hold, and also in the bin and feed trough. It invades store and warehouse, and destroys furs, laces, silks, carpets, leather goods, and groceries. It attacks fruits, vegetables, and meats in the markets, and destroys by pollution ten times as much as it actually eats. It carries disease germs from house to house and bubonic plague from city to city. It causes disastrous conflagrations; floods houses by gnawing lead water pipes; ruins artificial ponds and embankments by burrowing; destroys eggs and young poultry; eats the eggs and young of song birds and game birds; and damages foundations, floors, doors, and furnishings of dwellings.

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[a] Several species of rats are known as house rats, including the black rat (*Mus rattus*), the roof rat (*Mus alexandrinus*), and the brown rat (*Mus norvegicus*). Of these, the last is the commonest and most widespread in this country. Not one of these species is a native, but all were imported from the Old World. As their habits in general are similar, the instructions given in the bulletin apply alike to all.

MEANS OF REPRESSING RATS.

Rats have developed so much intelligence and such extraordinary caution that attempts to exterminate them have rarely succeeded. The failures have been due not so much to lack of effective methods as to the neglect of certain precautions and the absence of concerted action. We have rendered our work abortive by continuing to provide subsistence and hiding places for the rats. When these advantages are denied, persistent and concerted use of the methods here recommended will prove far more effective.

RAT-PROOF BUILDING.

First in importance, as a measure of rat repression, is the exclusion of the animals from places where they find food and safe retreats for rearing their young.

The best way to keep rats from buildings, whether in city or in country, is by the use of cement in construction. As the advantages of this material are coming to be generally understood, its use is rapidly extending to all kinds of buildings. Dwellings, dairies, barns, stables, chicken houses, ice houses, bridges, dams, silos, tanks, cisterns, root cellars, hotbeds, sidewalks, and curbs are now often made wholly of cement. The processes of mixing and laying this material require little skill or special knowledge, and workmen of ordinary intelligence can successfully follow the plain directions contained in handbooks of cement construction. Illustrated handbooks are often furnished free by cement manufacturers.

Many modern public buildings are so constructed that rats can find no lodgment in the walls or foundations, and yet in a few years, through negligence, such buildings often become infested with the pests. Sometimes drain pipes are left uncovered for hours at a time. Often outer doors, especially those opening on alleys, are left ajar. A common mistake is failure to screen basement windows which must be opened for ventilation. However the intruders are admitted, when once inside they intrench themselves behind furniture or stores, and are difficult to dislodge. The addition of inner doors to vestibules is an important precaution against rats. The lower part of outer doors to public buildings, especially markets, should be reenforced with light metal plates to prevent the animals from gnawing through.

Dwellings.—In constructing dwelling houses the additional cost of making the foundations rat-proof is slight as compared with the advantages. The cellar walls should have concrete footings, and the walls themselves should be laid in cement mortar. The cellar floor should be of medium rather than lean concrete, and all water and drain pipes should be surrounded with concrete. Even old cellars may be made rat-proof at comparatively small expense. Rat holes may be permanently closed with a mixture of cement, sand, and broken glass, or sharp bits of crockery or stone.

On a foundation like the one described above, the walls of a wooden dwelling also may be made rat-proof. The space between the sheathing and lath, to the height of about a foot, should be filled with concrete. Rats can not then gain access to the walls, and can enter the dwelling only through doors or windows. Screening all basement and cellar windows with wire netting is a most necessary precaution.

Old buildings in cities.—Aside from old dwellings, the chief refuges for rats in cities are sewers, wharves, stables, and outbuildings. Modern sewers are used by the animals merely as highways and not as abodes, but old-fashioned brick sewers often afford nesting crannies.

Wharves, stables, and outbuildings in cities should be so built as to exclude rats. Cement is the chief means to this end. Old tumbledown buildings and wharves should not be tolerated in any city.

In both city and country, wooden floors of sidewalks, areas, and porches are commonly laid upon timbers resting on the ground. Under such floors rats have a safe retreat from nearly all enemies. The conditions can be remedied in towns by municipal action, requiring that such floors should be replaced by others made of cement. Areas or walks made of brick are often undermined by rats, and may become as objectionable as those of wood. Wooden floors of porches should always be well above the ground.

Farm buildings.—Granaries, corncribs, and poultry houses may be made rat-proof by a liberal use of concrete in the foundations and floors; or the floors may be of wood resting upon concrete. Objection has been urged against concrete floors for horses, cattle, and poultry, because the material is too good a conductor of heat, and the health of the animals suffers from contact with these floors. In poultry houses, dry soil or sand may be used as a covering for the cement floor; and in stables, a wooden floor resting on the concrete is just as satisfactory so far as the exclusion of rats is concerned.

The common practice of setting corncribs on posts with inverted pans at the top often fails to exclude rats, because the posts are not high enough to place the lower cracks of the structure beyond reach of the animals. The posts should project at least 3 feet above the surface of the ground, for rats are excellent jumpers. But a crib built in this manner, though cheap, is unsightly.

For a rat-proof crib, a well-drained site should be chosen. The outer walls, laid in cement, should be sunk about 20 inches into the ground. The space within the walls should be thoroughly grouted with cement and broken stone and finished with rich concrete for a floor. Upon this the structure may be built. Even the walls of the crib may be concrete. Corn will not mold in contact with them, provided there is good ventilation and the roof is water-tight.

However, there are cheaper ways of excluding rats from either new or old corncribs. Rats, mice, and sparrows may be effectually kept out by the use of either an inner or an outer covering of galvanized-wire netting of half-inch mesh and heavy enough to resist the teeth of rats. The netting in common use for screening cellar windows is suitable for covering cribs. As rats can climb the netting, the entire structure must be screened.

KEEPING FOOD FROM RATS.

The effect of an abundance of food on the breeding of rodents should be kept in mind. Well-fed rats mature quickly, breed often, and have large litters. Poorly fed rats, on the contrary, reproduce less frequently and have smaller litters. In addition, scarcity of food makes measures for destroying the animals far more effective.

The general rat-proofing of buildings is the most important step in limiting the food supply of rats. But since much of the animals' food consists of garbage and other waste materials, it is not enough to bar rats from markets, granaries, warehouses, and private food stores. Garbage and offal of all kinds must be so disposed of that rats can not obtain them.

In cities and towns an efficient system of garbage collection and disposal should be established by ordinances. Waste from markets, hotels, cafés, and households should be collected in covered metallic receptacles and frequently emptied. Garbage should never be dumped in or near towns, but should be utilized or promptly destroyed by fire.

Rats find abundant food in country slaughterhouses; reform in the management of these is badly needed. Such places are centers of rat propagation. It is a common practice to leave offal of slaughtered animals to be eaten by rats and swine, and this is the chief means of perpetuating trichinæ in pork. The law should require offal to be promptly cremated or otherwise disposed of. Country slaughterhouses should be as cleanly as constantly inspected abattoirs.

Another important source of rat food is the remnants of lunches left by employees in factories, stores, and public buildings. This food, which alone is sufficient to attract and sustain a small army of rats, is commonly left in waste baskets or other open receptacles. Strictly enforced rules requiring all remnants of food to be deposited in covered metal vessels would make trapping far more effective.

If buildings are infested with rats, wire-screened compartments should be used for storing food. Many merchants now keep flour, seeds, meats, and the like in wire cages, and the practice should be general. Ice boxes and cold-storage rooms may be made proof against rats by an outer covering of heavy wire netting of half-inch mesh. Steamboat companies engaged in carrying high-priced southern produce to northern markets can, at small expense, protect the vegetables or fruits in screened compartments on both docks and vessels.

Rats do not gnaw the plane surfaces of hard materials, such as wood. They attack doors, furniture, and boxes at the angles only. This fact suggests the feasibility of protecting chests containing food by light coverings of metal along the salient angles. This plan has for years been in use to protect naval stores on ships and in warehouses.

NATURAL ENEMIES OF RATS.

Among the natural enemies of rats are the larger hawks and owls, skunks, foxes, coyotes, weasels, minks, dogs, cats, and ferrets.

Probably the greatest factor in the increase of rats, mice, and other destructive rodents in the United States has been the persistent killing off of the birds and mammals that prey upon them. Animals that on the whole are decidedly beneficial, since they subsist upon harmful insects and rodents, are habitually destroyed by some farmers and sportsmen because they occasionally kill a chicken or a game bird.

The value of carnivorous mammals and the larger birds of prey in destroying rats should be more fully recognized, especially by the farmer and the game preserver. Rats actually destroy more poultry and game, both eggs and young chicks, than all the birds and wild mammals combined; yet some of our most useful birds of prey and carnivorous mammals are persecuted almost to the point of extinction. An enlightened public sentiment should cause the repeal of all bounties on these animals and afford protection to the majority of them.

DESTRUCTION OF RATS.

The Biological Survey has made numerous laboratory and field experiments with various agencies for destroying rats. The results form the chief basis for the recommendations set forth in the following pages.

Traps.

Owing to their cunning it is not easy to clear premises of rats by trapping; if food is abundant, it is impossible. A few adults refuse to enter the most innocent-looking trap. And yet trapping, if persistently followed, is one of the most effective ways of destroying the animals.

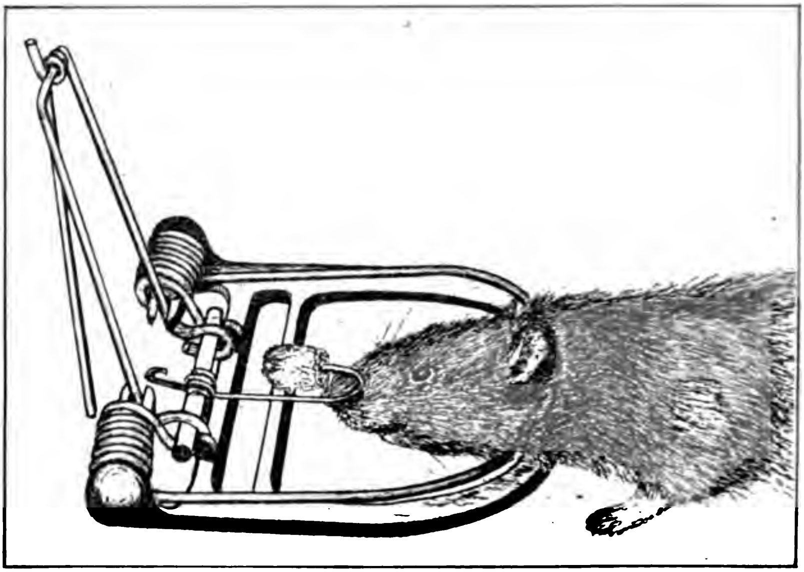

FIG. 2.—Method of baiting guillotine trap.

Guillotine trap.—For general use the improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called "guillotine" traps, are of many designs, but the more simply constructed are preferable. Probably those made entirely of metal are the best, as they are more durable and are less likely to absorb and retain odors.

Guillotine traps should be baited with small pieces of Vienna sausage (Wienerwurst) or fried bacon. A small section of an ear of corn is an excellent bait if other grain is not present. The trigger wire should be bent inward to bring the bait into proper position to permit the fall to strike the rat in the neck, as shown in the illustration (fig. 2).

Other excellent baits for rats are oatmeal, toasted cheese, toasted bread (buttered), fish, fish offal, fresh liver, raw meat, pine nuts, apples, carrots, corn, and sunflower, squash, or pumpkin seeds.

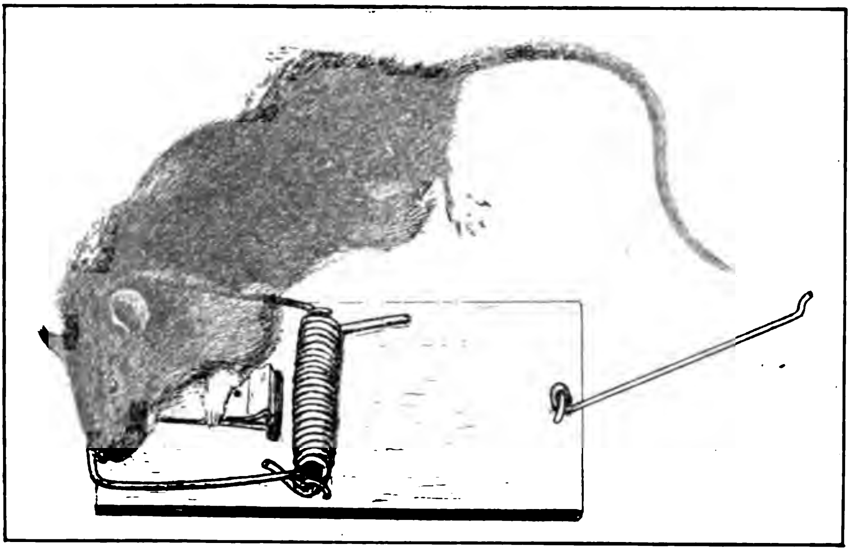

FIG. 3.—Rat caught in unbaited guillotine trap.

Broken fresh eggs are good bait at all seasons, and ripe tomatoes, green cucumbers, and other fresh vegetables are very tempting to the animals in winter. When seed, grain, or meal is used with a guillotine trap, it is placed on the trigger plate, or the trigger wire may be bent outward and the bait sprinkled under it.

The guillotine trap with wooden base and flat trigger pan is convenient for use along narrow rat runs, or at the mouth of burrows. It may be used in such places without bait (fig. 3).

Cage trap.—When rats are numerous, the large French wire cage traps can be used to advantage. They should be made of stiff, heavy wire, well reënforced. Many of those sold in hardware stores are useless, because a full-grown rat can bend the light wires apart and escape.

Cage traps should be baited and left open for several nights until the rats are accustomed to enter them to obtain food. They should then be closed and freshly baited, when a large catch may be expected, especially of young rats. As many as 25, and even more, partly grown rats have been taken at a time in one of these traps.

The writer has had excellent success by concealing a cage trap under a bunch of hay or straw, and has found by experience that a decoy rat in the trap is useful. A commission merchant in Baltimore places the baited cage trap inside of a wooden box having a hole in one end and against which the opening of the trap is fitted. The box is then covered with trash and large catches are made.

Notwithstanding the fact that sometimes a large number of rats may be taken at a time in cage traps, a few good guillotine traps intelligently used will prove more effective in the long run.

Figure-4 trigger trap.—The old-fashioned box trap set with a figure-4 trigger is sometimes useful to secure a wise old rat that refuses to be enticed into a modern trap. Better still is a simple deadfall—a flat stone or a heavy plank—supported by a figure-4 trigger. An old rat will go under such a contrivance to feed without fear.

Steel trap.—The ordinary steel trap (No. 0 or 1) may sometimes be satisfactorily employed to capture a rat. The animal is usually caught by the foot, and its squealing has a tendency to frighten other rats. The trap may be set in a shallow pan or box and covered with bran or oats, care being taken to have the space under the trigger pan free of grain. This may be done by placing a very light bit of cotton under the trigger and setting as lightly as possible. In narrow runs or at the mouth of burrows a steel trap unbaited and covered with very light cloth or tissue paper is often effective.

The best bait is usually food of a kind that the rats do not get in the vicinity. In a meat market, vegetables or grain should be used; in a feed store, meat. As far as possible, food other than the bait should be inaccessible while trapping is in progress. The bait should be kept fresh and attractive, and the kind changed when necessary. Baits and traps should be handled as little as possible. Ordinarily, traps should be frequently cleaned or smoked. The use of artificial scents, as oil of anise or rhodium, on the bait is advocated by many, but no doubt their importance has been exaggerated. The experience of the writer is not favorable to their use, but they may do some good by concealing the human odor on the trap.

Barrel trap.—About sixty years ago a writer in the Cornhill Magazine gave details of a trap, by means of which it was claimed that 3,000 rats were caught in a warehouse in a single night. The plan involved tolling the rats to the place and feeding them for several nights on the tops of barrels covered with coarse brown paper. Afterwards a cross was cut in the paper, so that the rats fell into the barrel (fig. 4 (1)). Many variations of the plan, but few improvements upon it, have been suggested by agricultural writers since that time. Reports are frequently made of large catches of rats by means of a barrel fitted with a light cover of wood, hinged on a rod so as to turn with the weight of a rat (fig. 4 (2)).

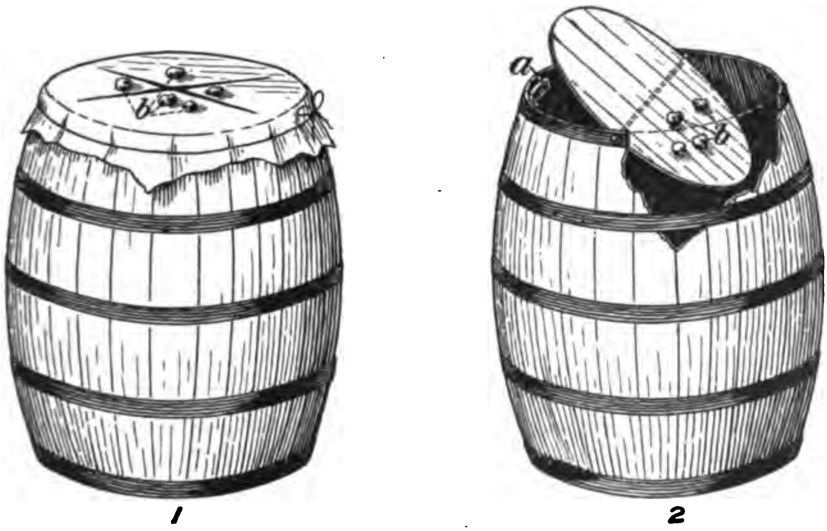

Fig. 4.—Barrel traps: 1, With stiff paper cover; 2, with hinged barrel cover; *a*, stop; *b*, baits.

Pit trap.—A modification of the barrel trap is the pit trap (fig. 5). This consists of a stout narrow box sunk in the ground so that the top is level with the rat run. It is fitted with a cover of light wood or metal in two sections, the sections fitting nicely inside the box and working independently. They turn on rods, to which they are fastened. They are weighted near the ends of the box and so adjusted that they swing easily. An animal stepping upon the cover beyond the rods is precipitated into the box, while the cover immediately swings back to its place. Besides

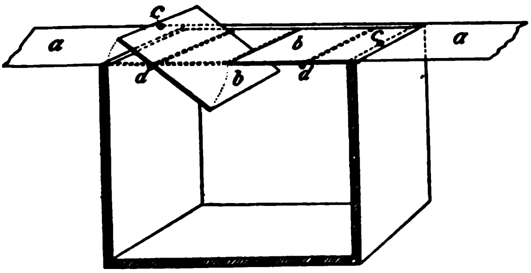

Fig. 5.—Pit trap. *aa*, Rat run; *bb*, cover; *cc*, position of weights; *dd*, rods on which covers turn.

rats, the trap is well adapted to capture larger animals, as mink, raccoons, opossums, and cats. It is especially useful to protect poultry yards, game preserves, and the like. The trap should be placed along the fence outside the yard, and behind a shelter of boards or brush that leans against the fence.

Fence and battue.—In the rice fields of the Far East the natives build numerous piles of brush and rice straw, and leave them for several days until many rats have taken shelter in them. A portable bamboo inclosure several feet in height is then set up around each pile in succession and the straw and brush are thrown out over the top, while dogs and men kill the trapped rodents. Large numbers are killed in this way, and the plan with modifications may be utilized in America with satisfactory results. A wire netting of fine mesh may be used for the inclosure. The scheme is applicable at the removal of grain, straw, or haystacks, as well as brush piles.

In a large barn near Washington, a few years ago, piles of unhusked corn shocks were left in the loft and were soon infested with rats. A wooden pen was set down surrounding the piles in turn and the corn thrown out until dogs were able to get at the rats. In this way several men and dogs killed 500 rats in a single day.

Poisons.

While the use of poison is the best and quickest way to get rid of rats, the odor from the dead animals makes the method impracticable in occupied houses. Poison, however, may be effectively used in barns, stables, sheds, cribs, and other outbuildings.

Among the principal poisons that have been recommended for killing rats are barium carbonate, strychnine, arsenic, and phosphorus.

Barium carbonate.—One of the cheapest and most effective poisons for rats and mice is barium carbonate. This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if taken in sufficient quantity. In the small doses fed to rats and mice it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible they usually leave the premises in search of water. For this reason the poison may frequently, though not always, be used in houses without disagreeable consequences.

Barium carbonate may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral, mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened), or ordinary bread and butter. The prepared bait should be placed in rat runs, about a teaspoonful at a place. If a single application of the poison fails to kill or drive away all rats from the premises, it should be repeated with a change of bait.

Strychnine.—Strychnine is too rapid in action to make its use for rats desirable in houses, but elsewhere it may be employed effectively. Strychnia sulphate is the best form to use. The dry crystals may be inserted in small pieces of raw meat, Vienna sausage, or toasted cheese, and these placed in rat runs or burrows; or oatmeal may be moistened with a strychnine sirup, and small quantities laid in the same way.

Strychnine sirup is prepared as follows: Dissolve a half ounce of strychnia sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. A smaller quantity may be prepared with a proportional quantity of water and sirup. In preparing the bait it is necessary to moisten all the oatmeal with the sirup. Wheat and corn are excellent alternative baits. The grain should be soaked overnight in the strychnine sirup.

Arsenic.—Arsenic is probably the most popular of the rat poisons, owing to its cheapness; yet our experiments prove that, measured by the results obtained, arsenic is dearer than strychnine. Besides, arsenic is extremely variable in its effect upon rats; and if the animals survive a first dose it is very difficult to induce them to take another.

Powdered white arsenic (arsenious acid) may be fed to rats in almost any of the baits mentioned under barium carbonate and strychnine. It has been used successfully when rubbed into fresh fish or spread on buttered toast. Another method is to mix twelve parts by weight of corn meal and one part of arsenic with whites of eggs into a stiff dough.

An old formula for poisoning rats and mice with arsenic is the following, adapted from an English source:

Take a pound of oatmeal, a pound of coarse brown sugar, and a spoonful of arsenic. Mix well together and put the composition into an earthen jar. Put a tablespoonful at a place in runs frequented by rats.

Phosphorus.—For poisoning rats and mice, phosphorus is used almost as commonly as arsenic, and undoubtedly it is effective when given in an attractive bait. The phosphorus paste of the drug stores is usually dissolved yellow phosphorus, mixed with glucose or other substances. The proportion of phosphorus varies from one-fourth of 1 per cent to 4 per cent. The first amount is too small to be always effective and the last is dangerously inflammable. When homemade preparations of phosphorus are used, there is much danger of burning the person or of setting fire to crops or buildings. In the Western States many fires have resulted from putting out homemade phosphorus poisons for ground squirrels, and entire fields of ripe grain have been destroyed in this way. Even with the commercial pastes the action of sun and rain upon them changes the phosphorus and leaches out the glucose until a highly inflammable residue is left.

It is often claimed that when phosphorus is eaten by rats or mice it dries up or mummifies the body so that no odor results. The statement has no foundation in fact. Equally misleading is the statement that rats poisoned with phosphorus do not die on the premises. Owing to its slower operation, no doubt a larger proportion escape into the open before dying than when strychnine is used.

The Biological Survey does not recommend the use of phosphorus as a poison for rodents.

Caution.—In the United States there are few laws which prohibit the laying of poisons on lands owned or controlled by the poisoner. Hence it is all the more necessary to exercise extreme caution to prevent accidents. In several States notice of intention to lay poison must be given to persons living in the neighborhood. Poison for rats should never be placed in open or unsheltered places. This applies particularly to strychnine or arsenic on meat.

Poison in poultry houses.—For poisoning rats in buildings and yards occupied by poultry the following method is recommended: Two wooden boxes should be used, one considerably larger than the other, and each having two or more holes in the sides large enough to admit rats. The poisoned bait should be placed on the bottom and near the middle of the smaller box, and the larger box should then be inverted over the other. Rats thus have free access to the bait, but fowls are excluded.

Domestic Animals.

Among domestic animals employed to kill rats are the dog, cat, and ferret.

Dogs.—The value of dogs as ratters can not be appreciated by persons who have had no experience with a trained animal. The ordinary cur and the larger breeds of dogs seldom develop the necessary qualities for ratters. Small Irish, Scotch, and fox terriers when properly trained are superior to other breeds, and under favorable circumstances may be relied upon to keep the farm premises reasonably free from rats.

Cats.—However valuable cats may be as mousers, few of them learn to catch rats. The ordinary house cat is too well fed and consequently too lazy to undertake the capture of an animal as formidable as the brown rat. Birds and mice are much more to its liking.

Ferrets.—Tame ferrets, like weasels, are inveterate foes of rats, and can follow the rodents into their retreats. Under favorable circumstances they are useful aids to the rat catcher, but their value is greatly overestimated. For effective work they require experienced handling and the additional services of a dog or two. Dogs and ferrets must be thoroughly accustomed to each other, and the former must be quiet and steady instead of noisy and excitable. The ferret is used only to bolt the rats, which are killed by the dogs. If unmuzzled ferrets are sent into rat retreats, they are apt to make a kill and then lie up after sucking the blood of their victim. Sometimes they remain for hours in the burrows or escape by other exits and are lost. There is danger that these lost ferrets may adapt themselves to wild conditions and become a pest by preying upon poultry and birds.

Fumigation.

Rats may be destroyed in their burrows in the fields and along river banks, levees, and dikes by carbon bisulphid. A wad of cotton or other absorbent material is saturated with the liquid and then pushed into the burrow, the opening being packed with earth to prevent the escape of the gas. All animals in the burrow are asphyxiated. Fumigation in buildings is not so effective, because it is difficult to confine the gases. Moreover, when effective, the odor from the dead rats is highly objectionable in occupied buildings.

Chlorin, carbon monoxid, sulphur dioxid, and hydrocyanic acid are the gases most used for destroying rats and mice in sheds, warehouses, and stores. Each is effective if the gas can be confined and made to reach the retreats of the animals. Owing to the great danger from fire incident to burning charcoal or sulphur in open pans, a special furnace provided with means for forcing the gas into the compartments of vessels or buildings is generally employed.

Hydrocyanic-acid gas is effective in destroying all animal life in buildings. It has been successfully used to free elevators and warehouses of rats, mice, and insects. However, it is so dangerous to human life that the novice should not attempt fumigation with it, except under careful instructions. Directions for preparing and using the gas may be found in a publication entitled Hydrocyanic-acid Gas against Household Insects, by Dr. L. O. Howard.[a]

Carbon monoxid is rather dangerous, as its presence in the hold of a vessel or other apartment is not manifest to the senses, and fatal accidents have occurred during its employment to fumigate vessels.

Chlorin gas has a strong bleaching action upon textile fabrics, and for this reason can not be used in many situations.

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[a] Circular 46, Bureau of Entomology, U. S. Dept. of Agric., 1907.

Sulphur dioxid also has a bleaching effect upon textiles, but less marked than that of chlorin and ordinarily not noticeable with the small percentage of the gas it is necessary to use. On the whole, this gas has many advantages as a fumigator and disinfectant. It is used also as a fire extinguisher on board vessels. Special furnaces for generating the gas and forcing it into the compartments of ships and buildings are on the market, and many steamships and docks are now fitted with the apparatus.

Micro-organisms.

Several micro-organisms, or bacteria, have been exploited in Europe and America for destroying rats. A number are on the market in the United States. With the aid of the Biochemic Division of the Bureau of Animal Industry, the Biological Survey has made laboratory and field experiments with some of them, and has also received many reports from others who have tried the cultures in a practical way. The results are by no means uniform, although the majority are negative. The cultures tested by the Survey have given poor results.

The chief defects to be overcome before the cultures can be recommended for general use are:

1. The virulence is not great enough to kill a sufficiently high percentage of rats that eat food containing the micro-organisms.
2. The virulence decreases with the age of the cultures. They deteriorate in warm weather and in bright sunlight.
3. The diseases resulting from the micro-organisms are not contagious and do not spread by contact of diseased with healthy animals.
4. The comparative cost of the cultures is too great for general use. Since they have no advantages over the common poisons, except that they are usually harmless to man and other animals, they should be equally cheap; but their actual cost is much greater. Moreover, considering the skill and care necessary in their preparation, it is doubtful if the cost can be greatly reduced.

Organized Efforts to Destroy Rats.

The necessity of cooperation and organization in the work of rat destruction should not be overlooked. To destroy all the animals on the premises of a single farmer in a community has little permanent value, since they are soon replaced from near-by farms. If, however, the farmers of an entire township or county unite in efforts to get rid of rats, much more lasting results may be attained. If continued from year to year, such organized efforts are very effective.

Cooperative efforts to destroy rats have taken various forms in different localities. In cities municipal employees have occasionally been set at work hunting rats from their retreats, with at least temporary benefit to the community. Thus, in 1904, at Folkestone, England, a town of about 25,000 inhabitants, the corporation employees, helped by dogs, in three days killed 1,645 rats.

Side hunts in which rats are the only animals that count in the contest have sometimes been organized and successfully carried out. At New Burlington, Ohio, a rat hunt took place November 26, 1866, in which each of the two sides killed over 8,000 rats, the beaten party serving a Thanksgiving banquet to the winners.

There is danger that organized rat hunts will be followed by long intervals of indifference and inaction. This may be prevented by offering prizes covering a definite period of effort. Such prizes accomplish more than municipal bounties, because they secure a friendly rivalry which stimulates the contestants to do their utmost to win.

In England and some of its colonies contests for prizes have been organized to promote the destruction of the European house sparrow, but many of the so-called sparrow clubs are really sparrow and rat clubs, for the destruction of both pests is the avowed object of the organization. A sparrow club in Kent, England, secured the destruction of 28,000 sparrows and 16,000 rats in three seasons by the annual expenditure of but £6 ($29.20) in prize money. Had ordinary bounties been paid for this destruction, the tax on the community would have been about £250 (over $1,200).

SUMMARY OF RECOMMENDATIONS.

The following are important aids in limiting the numbers of rats and reducing the losses from their depredations:

1. Protection of our native hawks, owls, and smaller predatory mammals—the natural enemies of rats.
2. Greater cleanliness about stables, markets, grocery stores, warehouses, courts, alleys, and vacant lots in cities and villages, and like care on farms and suburban premises. This includes the storage of waste and garbage in tightly covered vessels and the prompt disposal of it each day.
3. Care in the construction of buildings and drains, so as not to provide entrance and retreats for rats, and the permanent closing of all rat holes in old houses and cellars.
4. The early thrashing and marketing of grains on farms, so that stacks and mows shall not furnish harborage and food for rats.

5. Removal of outlying straw stacks and piles of trash or lumber that harbor rats in the fields.

6. Rat-proofing of warehouses, markets, cribs, stables, and granaries for storage of provisions, seed grain, and feedstuffs.

7. Keeping effective rat dogs, especially on farms and in city warehouses.

8. The systematic destruction of rats, whenever and wherever possible, by (*a*) trapping, (*b*) poisoning, and (*c*) organized hunts.

9. The organization of rat clubs and other societies for systematic warfare against rats.

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FARMERS' BULLETIN 370.

REPLANNING A FARM FOR PROFIT.

BY

C. BEAMAN SMITH,
Agriculturist,
AND
J. W. FROLEY,
Assistant Agriculturist,
Office of Farm Management, Bureau of Plant Industry.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 7, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Replanning a Farm for Profit," prepared jointly by Mr. C. Beaman Smith, Agriculturist, and Mr. J. W. Froley, Assistant Agriculturist, under the direction of the Agriculturist in Charge of the Office of Farm Management, of this Bureau.

Acknowledgments are due to the Bureau of Animal Industry of this Department for a critical reading of the manuscript and for helpful suggestions which have been embodied in the text.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
Difficulty of taking up a new line of farming 5
How shall the change be made? 5
Objections to giving advice on the management of entire farms 6
Farm plans must be based on average conditions 7
How farms are replanned by the Office of Farm Management 7
Replanning a farm in central Illinois 8
  General considerations in replanning the farm 8
  Some fundamental points to be kept in mind 9
  Plan 1.—A grain and hay farm 10
    Live stock to be kept 10
    Rotation to be followed 10
    Yields to be expected 11
    Financial returns to be expected 11
    The effect of adopting plan 1 12
  Plan 2.—A grain and clover-seed farm 13
    Possibilities of clover-seed farming 13
    Financial returns to be expected 14
  Plan 3.—A grain and clover farm 15
    Rotation to be adopted 15
    Live stock to be kept and yields to be expected 16
    Financial returns to be expected 16
  Plan 4.—A sheep farm 17
    Live-stock farming a complex problem 17
    Feeding system for fixed stock 18
    Acreage required to support fixed stock 19
    Flock management and feeding system 19
    Acreage required to support each ewe and her lamb 20
    Number of ewes the farm will carry 21
    Acreage of crops to be grown for feed 21
    Rotation to be followed 21
    Financial returns to be expected 22
    Pasturage responsible for low returns 22
  Plan 5.—A hog farm 23
    Pasture crops desirable for hogs 23
    Cropping plan 23
    Conditions assumed 24
    Number of brood sows that can be kept 25
    Pasture for hogs 25
    Financial returns to be expected 26

Replanning a farm in central Illinois—Continued. Page.

- Plan 6.—A dairy farm.......... 27
  - General considerations on dairy farming.......... 27
  - Conditions assumed.......... 27
  - Fixed stock on dairy farm.......... 28
  - Feeding system for stock.......... 28
  - Yields to be expected.......... 29
  - Acreage required for fixed stock and for buildings.......... 29
  - Number of cows and young stock that can be kept.......... 29
  - Feed consumed by one cow and corresponding young yearly.......... 30
  - Acreage of crops required for feed.......... 30
  - Rotation to be followed.......... 31
  - Financial returns to be expected.......... 32
  - Labor item on a dairy farm.......... 32
  - Increased investment necessary in dairy farming.......... 32
  - Increased productiveness of a dairy farm.......... 33

Summary of returns from different types of farming.......... 33
Plans given not model plans.......... 34
The problem of replanning a farm.......... 35
Why low returns are realized from some farms.......... 35
Summary.......... 36

B. P. I.—496.

REPLANNING A FARM FOR PROFIT.

INTRODUCTION.

Habit frequently continues a type of farming in a community long after that type has become unprofitable. Wheat farming on fertile virgin soil is usually profitable, but there are many instances in the United States where farmers have continued to grow wheat for a number of years after it had ceased to be a profitable crop. The same is true of cotton. A two-year rotation of corn and oats has been continued in portions of the corn belt, notwithstanding the fact that it is often unprofitable, little or no money being made on either crop. Frequently these unprofitable types of farming continue through a series of years or until the property changes hands or new methods are introduced. The farmer finds it hard to change a lifelong habit.

DIFFICULTY OF TAKING UP A NEW LINE OF FARMING.

A man who has grown up with the agriculture of a community is slow to believe that the type of farming he has followed and which was at one time profitable has at last become unsuited to his conditions. It is no small task to think out and change his long-used type to some better kind of farming. There are several reasons why such a change is difficult. It may mean a new line of equipment. Buildings may need modification or fences must be rearranged. It may mean the introduction of commercial fertilizers or of more or different live stock on the farm. It may mean that money will have to be borrowed if the proposed changes are effected. Furthermore, the change may not succeed. At best the taking up of a new line of farming requires a readjustment of the usual ways of thinking and doing, a thing difficult in itself and requiring considerable time to accomplish.

HOW SHALL THE CHANGE BE MADE?

Notwithstanding habit may set the farmer in his ways, altered conditions and lessened yields and income may compel him to change his system or go out of business. To what shall he change? How shall be go about it? What type of farming is likely to prove more

370

profitable than the kind he is now following? What additional capital is necessary to institute a new and better system? These are the questions that confront him. They are difficult to answer. With pencil and paper in hand he may estimate the returns that may reasonably be expected by introducing more crops that build up the land, by growing more of the crop that is bringing him in the greatest amount of money, by giving more attention to the live stock that has been found to pay best, and the like.

If in these calculations he meets with difficulty because of a lack of definite information as to what may be reasonably expected when improved methods are applied in the culture of a crop or in the handling of stock, he may write to the agricultural college, or the board of agriculture, or the agricultural experiment station of his own State, or to the United States Department of Agriculture for help. It is the business of these institutions to discover and gather facts relative to the science, practice, and business of agriculture for the benefit of the farmer, and particularly for the farmer who wants to improve his methods of farming. The agricultural press also undertakes to aid the farmer in the solution of problems of this character.

In addition to these sources a few private firms have been established whose business it is to furnish expert advice on farm management for a consideration.

OBJECTIONS TO GIVING ADVICE ON THE MANAGEMENT OF ENTIRE FARMS.

Not always, however, are the institutions just mentioned prepared to give the farmer information on a plan covering his whole farm. The expert dairyman cares to give advice only on dairying, the entomologist only on insects and spraying, the agronomist only on field crops, the pathologist only on plant diseases, the shepherd only on sheep. Not many care to attempt to coordinate all the manifold interests of the farm into a single comprehensive farm plan, and yet this is exactly what the farmer must do every day of his life if he would get the most out of his farm and make farming pay.

The farmer is not simply a corn farmer, or a wheat grower, or a cattle breeder, or a sheep feeder, or a poultry raiser, but often all of these and more combined. His farm, therefore, must be planned with reference to all of these operations and the harmonious dovetailing together of the different parts. In replanning his farm for profit the farmer must see all these different problems in a comprehensive way at the outset, omit the features that do not pay, and strengthen those that do.

Fortunately, many of our agricultural colleges to-day are coordinating the work of their different departments and giving courses in farm management, and usually suggestions can be obtained from these sources relative to the general management of the farm—not necessarily detailed directions for farming, for it would be as difficult to tell a man how to farm as it is to tell him how to succeed in law, but rather to furnish him a comprehensive plan for managing his farm, corresponding in a way to the plan furnished by the architect to a builder.

FARM PLANS MUST BE BASED ON AVERAGE CONDITIONS.

It is often said that a farm can not be planned as other kinds of business are; that the vicissitudes of weather, the visitations of insect pests or plant diseases, the low prices that may prevail when the farmer has to sell, and other unforeseen circumstances may interfere to make all farm plans almost worthless from a practical standpoint.

This is often quite true with reference to plans made for a particular year. But when the plans are based on average conditions for a long series of years, then the objections do not hold. For while we can not tell what may happen during any particular season, we can foretell with considerable accuracy what the average conditions will be over a series, say, of ten years. The whole business of insurance is based on the reliability of averages. It can not be foretold just who out of a thousand persons will die next year, but it can be stated with much certainty about how many persons out of the thousand will die. Plans for the farm, likewise, must represent and be based on average conditions and not on single years. The farm plan must be made for a period of years and not for a single year.

HOW FARMS ARE REPLANNED BY THE OFFICE OF FARM MANAGEMENT.

The United States Department of Agriculture is in almost daily receipt of letters to the following effect: The writer owns a farm. The farm is not paying. Can the Department suggest a kind of farming that will pay?

This correspondence is usually referred to the Office of Farm Management of the Bureau of Plant Industry for reply. It is to show how the Office of Farm Management handles such problems as these, and thus to indicate to the farmer the capabilities of a farm when replanned for profit and how he may go about replanning his own farm, that this bulletin is written.

REPLANNING A FARM IN CENTRAL ILLINOIS.

For the purpose of illustration, the problem of an 80-acre farm reported to the Office of Farm Management from central Illinois may be taken. The owner stated that his farm was located on the black prairie corn land common to that section of the State, that it was valued at $150 to $175 an acre, would rent for $5 an acre cash, and that it had been cropped with corn and oats for many years until the average yields were about 35 bushels of corn per acre or 20 bushels of oats.

In 1908 the actual yields were 24 bushels of corn and 12 bushels of oats per acre. The total income of the whole farm, estimating crops at average prices, was less than $450 for the year, from which it will be readily seen that the labor and capital invested are not very handsomely rewarded. In fact, if the labor on the farm were hired the farm would be run at a considerable loss. Valuing the farm at $12,000, the interest alone at 5 per cent is $600.

This farm was chosen for illustration because it is typical of large farming areas in parts of the Middle States and because the price of the land has outgrown the system of farming in vogue.

In the future management of this farm three propositions are open to the owner: (1) Continue the old method of farming and lose money; (2) rent the land out at $5 per acre cash and permit the land to be further robbed of soil fertility and impoverished; and (3) change his plans to meet the new conditions and farm rationally and profitably.

In replanning this farm it was decided as a preliminary to make general estimates of the returns that might be expected if the farm were operated along any one of the following lines:

(1) A grain and hay farm, with a three-year rotation of corn, oats, and hay.

(2) A grain and clover-seed farm, with a three-year rotation of corn, oats, and clover for seed.

(3) A grain and clover farm, with a four-year rotation of corn, corn, oats, and clover.

(4) A sheep farm.

(5) A hog farm.

(6) A dairy farm.

GENERAL CONSIDERATIONS IN REPLANNING THE FARM.

Among the first things essential to know in replanning a farm is what can reasonably be expected from the farm if properly handled. Judgment on this point will be considerably influenced by what is being done by good farmers on similar land elsewhere under like conditions.

The usual crops grown in the vicinity and the usual rotation on most of the farms of the neighborhood are corn and oats. But very little hay is raised, notwithstanding both clover and timothy do well, nor is much stock fed. Some colts are raised, but most of the grain is sold direct to the elevator.

In the early days, when the land was new, corn yielded 75 to 80 bushels per acre and oats 40 bushels, and this type of farming—corn in rotation with oats—was very profitable. At the present time on similar land and within 10 miles of the farm in question one extensive farmer has been able to maintain the average yield of both corn and oats for a period of sixteen years at 40 bushels per acre. Even on this farm scarcely 15 per cent of the area is yearly planted to clover, and no commercial fertilizer and practically no stable manure is used.

With a proper system of rotation, the introduction of clover into the farming scheme, and the use of comparatively small quantities of commercial fertilizers where barnyard manure is not available, it should be easily possible to make the average yields of corn on this farm 60 to 75 bushels per acre and of oats 40 to 45 bushels.

This estimate is based on the fact that in a thirty-year rotation experiment at the University of Illinois the yield of corn in a rotation of corn, oats, and clover has averaged 58 bushels per acre, and when treated with lime and phosphorus in addition for thirteen years the average yield of corn per acre has been 90 bushels.[a] Our first thought, therefore, in replanning this farm is to introduce clover into the rotation and to use some form of commercial fertilizer that will maintain the fertility of the soil and increase the yield of money crops.

SOME FUNDAMENTAL POINTS TO BE KEPT IN MIND.

In replanning a farm it is essential that a few fundamental points in farming be kept constantly in mind:

(1) The plan should provide a reasonable reward for the labor and capital invested.

(2) The fertility of the farm should be maintained or increased.

(3) The plan must be suited to the capabilities of the owner for carrying it out.

It is assumed that in order to replan a farm for profit it is necessary to consider the capabilities of the farmer to put the new plan into effect. This, in general, will render it necessary to recombine the phases of farming with which he is already familiar or to bring in new features which are not very dissimilar to the ones he is already accustomed to. That is why in plan 1 the only change made is the addition of clover to the rotation, with a little bone meal to increase the corn crop.

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[a] See Illinois Agricultural Experiment Station Bulletin 125, p. 324.

PLAN 1.—A GRAIN AND HAY FARM.

Live stock to be kept.

To successfully handle an 80-acre farm of heavy soil on which corn, oats, and hay are grown, about four work animals will be needed. These may well be draft brood mares, and it may safely be assumed that each mare will produce on an average a colt every other year. To supply the family with milk and butter, about two cows will be needed. The farmer will probably raise two or three hogs for pork and will keep a few chickens. It is assumed that the permanent pasture for two cows and two colts during the season, and possibly two or three hogs, depending on whether it may or may not be cheaper and less troublesome to buy pork than to put up hog fences and feed corn, together with the buildings, garden, and orchard, will require about 8 acres (ordinarily a cow requires 2 acres of pasture each season), thus leaving 72 acres of the farm which can be put into cultivated crops.

Rotation to be followed.

These 72 acres will be divided into three fields of 24 acres each without division fences, and a three-year rotation of crops will be observed as follows:

One 24-acre field will be planted with corn, using selected seed and fertilizing the field with all the barnyard manure available, and in addition applying about 400 pounds of steamed bone meal per acre. As this land still produces a luxuriant crop of clover no lime will be added at present other than that contained in the bone meal. The corn crop will be cultivated, not necessarily the regulation three times and then laid by, but as often as may be necessary to keep the upper 2 or 3 inches of soil loose, mellow, and free from weeds. The corn will be planted on a clover sod which has been plowed down in the fall and left rough through the winter.

The second 24-acre field will be planted to oats, or possibly winter wheat, as winter wheat is again coming into favor with farmers in the section. The oats will be put in on corn ground which has [illegible] thoroughly disked and put into fine condition for this crop. No fertilizer will be used on the oats. Selected seed of the Swedish Select variety or of some other variety that does well in the neighborhood will be sown. With the oats and ahead of the drill a mixture of about 10 pounds of common red clover and 12 pounds of timoth will be sown.

The third 24-acre field will be in hay, the timothy and cl mixture seeded with the oats the preceding year.

Yields to be expected.

In this first replanning of the farm, then, provision has been made for a three-year rotation of corn, oats, and clover, each to occupy the same field but one year before that field is refitted for another crop in the rotation. The total average yields that may be expected from this rotation after it is put into operation are about as follows:

Corn, 24 acres, at 60 bushels per acre	bushels	1,440
Oats, 24 acres, at 40 bushels per acre	do	960
Hay, 24 acres, at 2 tons per acre	tons	48

Feed required for stock.—All of this produce can not be sold, however. The stock must be fed, and for this purpose it is assumed that the following quantities will be required throughout the year for the different kinds of stock:

	Pounds.
4 mares, grain fed, 15 pounds each daily	21,900
2 colts, grain fed, 1 pound each, 300 days	600
2 cows, grain fed, 4 pounds each, 180 days	1,440
Total	23,940

The figures given are averages. It is expected that the grain fed the heavy type of draft horses kept on this farm will average nearer 20 pounds during the busiest part of the working season and considerably less than 15 pounds in winter. Usually in winter, when but little farm work is going on, only one team will be fed grain. In the above estimates no account is taken of the hay fed to stock, as it is the custom in the section to use oat straw and corn stover as the only roughage either winter or summer.

If this farm were being planned for the greatest profit instead of for the purpose of showing the various ways in which the problem may be attacked, less grain and more clover hay would be fed. In fact, all the hay produced on the place would be fed to stock of some kind bought or raised for the purpose.

Financial returns to be expected.

Since the roughage (oat straw and corn stover) fed both horses and cows is of a highly carbonaceous nature, the grain ration may well be straight oats, which is fairly rich in protein, instead of a mixture of oats and corn, which is commonly employed in the region. The 23,940 pounds of grain required to feed the stock represents about 750 bushels of oats. There will be required for seed each year also about 60 bushels of oats, making in all 810 bushels that will be consumed on the place. The remainder of the oats grown, together with all the corn, all the hay, 2 colts, and probably 2 veal calves, may be sold each year and will constitute the gross income of the farm. The gross returns may be expected to be about as follows:

Corn, 1,440 bushels, at 50 cents a bushel	$720
Oats, 150 bushels, at 40 cents a bushel	60
Hay, 48 tons, at $8 a ton	384
Colts, 2, at $50 each	100
Calves, 2, at $5 each	10
Total gross income	1,274

From the $1,274 gross income should be deducted the cost of about 5 tons of steamed bone meal at $25 a ton, leaving a balance of $1,149 as the gross returns, out of which must come the expenses of labor, living, interest on investment, etc.

The effect of adopting plan 1.

In this first outline plan it is seen that by the introduction of hay, a large part of which is clover, into the rotation, thus augmenting the humus and nitrogen content of the soil, and by the addition of 400 pounds to the acre of steamed bone meal on each crop of corn, it may be expected that the yields will be doubled and the income raised from less than $450 to $1,149 a year, with all expense charges remaining practically the same as before, and in addition $125 paid out for steamed bone meal to help maintain the fertility of the farm. These results would not be secured the first year. The fertilized corn crop would first show the results of the system and not until the third year could the above results be expected.

The nearly 12 tons of grain fed, together with the 24 acres of oat straw and 24 acres of corn stover fed or used as bedding on the place, will make more than 100 tons of manurial material to be used on the corn. This, with the plowed-under clover stubble, will keep the farm fairly well supplied with humus. The 400 pounds of bone meal used on the corn, with that furnished by the manure, will more than supply the phosphoric acid removed by all the crops, and the only element of importance permanently decreased in the soil is potash. There is such an abundant supply of potash, however, in Illinois corn soils that this factor can probably be neglected for several generations yet.

In the above plan, should the farmer desire to feed about three hogs for pork, he should let them run on pasture, and can estimate that it will require about 15 bushels of corn each to bring them to a weight of 200 pounds at 10 months.

The income of $1,149 per annum by the system of farming outlined in plan 1 will pay only 5 per cent interest on a $15,000 investment and leave but $399 to pay taxes, running expenses, labor, etc., so further changes will be made as suggested in the following plan.

PLAN 2.—A GRAIN AND CLOVER-SEED FARM.

In plan 1, just described, the usual system of operating the 80-acre farm was modified in only one important particular. The rotation of corn and oats was changed to a three-year rotation of corn, oats, and clover and timothy hay, and the hay was sold for $8 a ton. Instead of selling the hay, suppose only clover seed is sown—either mammoth, common red, or alsike—and the whole crop saved for seed. How would this change affect the income and fertility of the farm?

The live stock kept on the farm would be 4 brood mares, 2 cows, and 2 colts, as before. The method of feeding them would be the same. One man could do practically all the work on the farm, as before. The 400 pounds of bone meal per acre would be applied on the corn crop each year, but instead of attempting to put up or market hay, only clover seed would be sown and attention centered on the production of a heavy clover-seed crop. The rotation would be (1) corn, (2) oats, (3) clover for seed.

Possibilities of clover-seed farming.

What are the possibilities of clover seed as a standard farm crop? As commonly handled—the first crop cut for hay and the second crop taken for seed—the average yields vary from a peck to occasionally 2 bushels per acre. Thus handled, clover seed is a precarious crop and there is practically no money in it. But farmers are known in Ohio and Illinois who make a business of growing clover for seed each year and who count with as much certainty on getting yields of 4 bushels of seed per acre as they do on getting 50 bushels of corn per acre each year on good corn land.

To secure seed the clover-seed farmer aims to make his clover bloom in dry weather. He reduces the quantity of stem, and instead of a rank-growing plant that lodges badly he will have a short, stocky, upright clover plant. Likewise he aims to have only a medium thick stand of clover on the field when he grows it for seed, and so will use much less seed at planting time than when the crop is grown for hay. And probably most important of all, the successful clover-seed farmer will make his clover bloom at a time when the insects[a] which injure the seed most are for the most part undergoing their transformations in the ground.

Usually all of the results referred to are accomplished by pasturing the clover back in northern Illinois to about June 1 to 10, or clipping the clover with the mower at about the same time and letting the clippings lie on the ground. It is not usually possible to get both a good hay crop and a good clover-seed crop the same season. Generally the hay crop must be sacrificed or cut considerably earlier than usual.

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[a] What these insects are, their nature, and how to avoid them may be learned in detail by a study of Circular No. 69 of the Bureau of Entomology, United States Department of Agriculture, entitled "Some Insects Affecting the Production of Red Clover Seed."

An instance is known of a 50-acre field of clover in Illinois, not far from the 80-acre farm here being considered, where haying was begun one season about ten days earlier than usual and finished about the usual time. The whole of the second crop was then saved for seed. On the part cut earliest for hay the seed obtained at the second cutting averaged close to 5 bushels per acre for common red clover. On that portion of the field cut last for hay the seed yield of the second crop was scarcely 1 bushel per acre. By cutting hay early the ravages of the clover-flower midge, which prevents clover-seed formation, were largely avoided and a good seed crop obtained.

Financial returns to be expected.

In the second plan it is assumed that if a farmer understands his business he can get average yields of at least 3 bushels of clover seed per acre. Assuming yields of 60 bushels of corn per acre and 40 bushels of oats, as before, that the stock will require the same quantity of feed as in plan 1, and that prices will be 50 cents per bushel for corn, 40 cents for oats, and $6 for clover seed, there will be for gross income the following:

Corn, 24 acres, 1,440 bushels, at 50 cents	$720
Oats (feed and seed, 810 bushels), 150 bushels, at 40 cents	60
Clover seed, 24 acres, 72 bushels, at $6	432
2 colts at $50 each	100
2 calves at $5 each	10
Total income	1,322

From this gross income of $1,322 will be deducted $125 for 5 tons of bone meal, leaving $1,197 to pay for labor, interest on investment, and other charges against the farm.

The growing of the clover for seed instead of for hay is thus seen to be even more profitable than the hay proposition. The labor of harvesting the seed is much less exacting than handling the crop for hay, and if a rain or two should come after the seed crop is cut the damage is far less than in the case of the hay crop.

Besides, instead of the hay being sold, resulting in considerable loss of soil fertility to the farm, all the clover straw and chaff would be returned to the fields and the fertility of the soil maintained much more surely than by plan 1.

It is thus seen that by simply modifying the present system of corn and oat growing on this farm by the addition of clover grown for either hay or seed the gross income is more than doubled and the land greatly improved at the same time. The returns from this system of farming will just about pay 5 per cent interest on a $15,000 investment and moderate wages to one man for the year. It would not satisfy the man who had bought a farm and was trying to pay for it out of the proceeds of the farm.

PLAN 3.—A GRAIN AND CLOVER FARM.

If the crops grown on this farm and the prices received for them are examined critically, attention is attracted at once to the fact that the largest return per acre, $30, is secured from the corn crop. From the standpoint, therefore, of profit and the use of the crops here under consideration it is desirable to grow as large an acreage of corn each year as is consistent with good farming.

Some of the important factors that must be kept in mind in increasing the acreage of corn are the insects that affect the crop injuriously when grown too many seasons on the same field in succession, the necessity of maintaining the nitrogen and humus supply in the soil by the culture of some leguminous crop, and the supplying of adequate amounts of certain mineral fertilizers, like the phosphates, to secure maximum corn crops and insure the continued productiveness of the farm.

Rotation to be adopted.

A rotation which has been found satisfactory and effective in parts of the corn belt and which puts half the farm in corn each year is as follows: (1) Corn, (2) corn, (3) oats, (4) clover. This is a four-year rotation in which half the fields are in corn each year. It is true that in this rotation corn follows corn for two years, but this is not particularly objectionable on good corn ground, especially when, following corn, the field is given two years' rest from this crop and opportunity is thus afforded to free the land from the more serious pests of the corn. This is also a type of farming differing but little from that already in operation on the farm under consideration, and hence easy to adopt.

If it be assumed, as in previous plans, that 8 acres of the farm are devoted to buildings, yards, garden, orchard, and permanent pasture for the cows, colts, and calves, there will remain 72 acres to fit into this four-year rotation. These 72 acres, therefore, may be divided into four 18-acre fields and each year there will be grown (1) 18 acres of corn, (2) 18 acres of corn, (3) 18 acres of oats, and (4) 18 acres of clover. The corn will be fertilized each year with about 400 pounds of steamed bone meal per acre.

Live stock to be kept and yields to be expected.

As in previous plans, it is assumed that the stock kept on the farm will be 4 brood mares, 2 colts, and 2 cows. It has already been shown that to feed the fixed stock on the farm about 23,940 pounds of grain will be needed. In feeding the grain and for seed all the oats grown on the farm, about 720 bushels, will be needed, and about 45 bushels of corn in addition. The roughage and bedding for stock will consist of corn stover and oat straw. The clover may be handled either for seed or hay.

As the hay crop in the hands of the ordinary farmer is a little more certain than the seed crop, this phase will be considered in making the final calculations.

The average yield expected will be as follows:

Corn, 36 acres, at 60 bushels per acre	bushels	2,160
Oats, 18 acres, at 40 bushels per acre	do	720
Clover hay, 18 acres, at 2 tons per acre	tons	36

Financial returns to be expected.

Of the oats, 40 bushels will be used for seed and all the remainder fed.

Of the 2,160 bushels of corn, all but 45 bushels will be sold. All the clover hay will be sold. The average gross returns of the farm from all sources should be about as follows for the four-year rotation:

Corn, 2,115 bushels, at 50 cents	$1,057.50
Clover hay, 36 tons, at $8	288.00
2 colts, at $50 each	100.00
2 calves, at $5 each	10.00
Total	1,455.50

The amount of bone meal bought for the corn will be increased from 5 to 7 tons, which will cost about $175, leaving $1,280.50 as a return for the year's expenses, interest, and labor.

If the clover were harvested for seed instead of hay the returns for the clover crop would be $324 instead of $288, and in addition all the clover straw, which is worth as a fertilizer practically $8 a ton, would be left on the land as a permanent improvement instead of being sold off for hay.

The gross returns secured by thus adopting a four-year rotation instead of a three-year rotation and by increasing the acreage in corn have been increased from $130 to $160 over plan 1 and from $80 to $116 over plan 2, while as compared with the farm as at present planned the returns are 2.8 times as great. This plan yields a return of about 5 per cent on a $15,000 investment, and leaves from $530 to $566 to pay expenses, wages, etc.

To show the effect of making live stock the leading feature of the farm, plans showing the returns that may be expected by certain methods of handling different classes of stock will now be taken up.

PLAN 4.—A SHEEP FARM.

Of all the different types of agriculture, live-stock farming is the surest way known to increase yields and keep up permanently the fertility of the farm or to build up the farm after it has once been run down by years of grain, cotton, or tobacco farming. The owner of the 80-acre farm here under consideration was conscious of this fact and thought possibly he might go into some kind of stock farming. Would it pay? He liked sheep; people said there was "money in sheep." He desired that in replanning the farm its possible conversion into a sheep farm be considered. To meet this request, therefore, the farm has been planned along one of the more usual lines of sheep farming common to Illinois to see about what returns might be expected.

Live-stock farming a complex problem.

The introduction of stock on the farm complicates matters considerably in planning a cropping system which shall fit the needs of the stock kept and in estimating expenses and returns. First of all, in the present instance, it is necessary to know how many sheep an 80-acre farm will carry. Before this question can be answered it must be known roughly how much "fixed stock," like horses and cows, will be kept on the place, since it will require a certain amount of land to grow crops for this "fixed stock," and it is only the area that is left that can be counted on for pasture and crops for the sheep. In the previous plans, where an excess of grain and roughage was grown, the acreage of crops required for the fixed stock did not necessarily enter into the problem except as regards final returns. Now, however, the number of fixed stock kept and what they eat will be a limiting factor on the number of sheep that can be kept, and must be known at the outset.

In order that the plan for the farm may be in a measure comparable with the plans previously outlined it will be assumed at the outset that 4 brood mares will be kept for farm work, 2 colts raised yearly, 2 cows kept for family use, and 2 calves sold for veal.

Good sheep farming presupposes the growing of considerable clover or other leguminous hay. With clover hay for feed, an efficient ration for practically all this stock can be made, with corn as the principal grain ration. Some oats, perhaps, should be grown for the colts and cows, and some will be needed in starting lambs on grain rations, but as corn weighs more per bushel and yields more bushels per acre than oats, it is desirable to use corn instead of oats whenever possible.

Feeding system for fixed stock.

The fixed stock or permanent stock on the place will be fed about as follows:

Horses.—An average each of 15 pounds of corn, 10 pounds of clover hay, and 5 to 10 pounds of cornstalks daily throughout the year.

Colts.—Run in permanent pasture; for about 300 days they will be fed an average of 1 pound of oats daily, and for 120 days of this time they will each be fed an average of 1½ pounds of clover hay a day. They will be sold before they are a year old.

Cows.—Run on permanent pasture from May 1 to October 31. From November 1 to April 30, or about 180 days, each will be fed an average of 4 pounds of corn and oats, half and half, with 5 pounds of clover hay and cornstalks or oat straw in addition.

The grain and hay required for this stock during the year will be about as shown below:

	Pounds.
Corn:	
4 horses, 15 pounds each, 365 days	21,900
2 cows, 2 pounds each, 180 days	720
Total corn	22,620
Oats:	
2 cows, 2 pounds each, 180 days	720
2 colts, 1 pound each, 300 days	600
Total oats	1,320
Hay:	
4 horses, 10 pounds each, 365 days	14,600
2 cows, 5 pounds each, 180 days	1,800
2 colts, 1½ pounds each, 120 days	360
Total hay	16,760

The above data indicate that for the fixed stock there will be required yearly 22,620 pounds of corn, 1,320 pounds of oats, and 16,760 pounds of hay.

With this type of farming, in which all of the crops grown on the farm are consumed on the farm and where clover will constitute the principal hay and pasture crop, it is assumed, as in previous plans, that the yields will be 60 bushels, or 3,360 pounds, of corn; 40 bushels, or 1,280 pounds, of oats; and 2 tons of clover hay per acre on the average each year.

Acreage required to support fixed stock.

With the above data in hand it is possible to determine the amount of land that will be required to support the fixed stock on the farm. This is shown in the table below.

TABLE 1.—*Acreage of corn, oats, and hay required by fixed stock.*

Kind of feed required.	Total quantity required.	Yield of 1 acre.	Total area of each crop required.
	Pounds.	*Pounds.*	*Acres.*
Corn	22,620	3,360 (60 bushels)	6.73
Oats	1,320	1,280 (40 bushels)	1.03
Hay	16,760	4,000 (2 tons)	4.19
Total acreage required			11.95

This table shows that about 12 acres of the farm must be devoted to growing hay and grain for the fixed stock. If to the 12 acres of corn, oats, and hay required for the fixed stock 8 acres more are added for the buildings, orchard, garden, and permanent pasture for the cows, colts, and pigs, there will be left for sheep only 60 acres of the farm. The problem now is, How many sheep will this area support? What is the maximum number of ewes that can be maintained on this area and what are the average returns that may be expected per annum?

To answer these questions it is first necessary to find out how much land will be required to support one sheep. This, in turn, depends on what the sheep eats, and so at the outset it is found necessary to adopt a feeding system and plan of management for the flock.

Flock management and feeding system.

Good grade Merino-Shropshire ewes will be used and pure-bred bucks of either the Shropshire, Oxford, Hampshire, or Southdown breeds. It is assumed that on the average each ewe in the flock will drop one lamb. It is planned to have the lambs dropped in February and sold the last of June or first of July, at a weight of from 40 to 50 pounds. This will avoid carrying the lambs through the hot summer months, when pastures are short, gains slow, and danger from infestation by stomach worms great. Besides, the ewes will be relieved by weaning the lambs at this season of the year and more pasture will be available for grazing; hence, more ewes can be kept and the ewes will be in better condition for September and October breeding.

The general scheme of feeding ewes and lambs will be about as follows:

Ewes.—The ewes will run at pasture from May 1 to November 30, and it is assumed that an acre of good clover pasture will support about 4 ewes with their lambs. From December 1 to April 30 the ewes will receive about 3 pounds of clover hay daily, and in addition during the month of February, when the lambs are coming, each ewe will be fed about 1 pound of oats daily, while during March and April the same quantity of grain will be fed the ewes with the idea of thus increasing the growth of the lambs, but half the grain will be oats and the other half corn.

Lambs.—The lambs will run with the ewes up to the time they are sold, and from March 15 to June 30 will each receive daily on the average about three-eighths of a pound of corn until sold the latter part of June or early in July.

The total quantity of grain and hay that will be required for each ewe and her lamb during the year will be about as follows:

Ewes:	Pounds.
Hay, December 1–April 30, 151 days, fed 3 pounds daily	453
Oats, February 1–28, 28 days, fed 1 pound daily	28
Oats, March 1–April 30, 61 days, fed ½ pound daily	30.5
	58.5
Corn, March 1–April 30, 61 days, fed ½ pound daily	30.5
Lambs: Corn, March 15–June 30, 107 days, fed ⅜ pound daily	40.1
	70.6

Acreage required to support each ewe and her lamb.

As shown, each ewe and her lamb will require during the year a total of 453 pounds of hay, 58.5 pounds of oats, and 70.6 pounds of corn. In addition it has been assumed that they will also require one-fourth acre of pasture. The total area of land, then, required for each ewe and lamb for grain, hay, and pasture will be as shown in the following table:

TABLE 2.—*Acreage of corn, oats, hay, and pasture required by each ewe and her lamb during a season.*

Kind of feed required.	Total quantity required.	Yield of 1 acre.	Total area of each crop required.
	Pounds.	*Pounds.*	*Acres.*
Corn	70.6	3,360 (60 bushels)	0.021
Oats	58.5	1,280 (40 bushels)	.046
Hay	453.0	4,000 (2 tons)	.113
Pasture			.250
Total acreage for each ewe and her lamb			.430

In the above table the figures showing acreages in the last column are obtained by dividing the amount of feed required for each head by the quantity that can be produced on an acre. They show that there must be grown for each ewe and her lamb 0.021 of an acre of corn, 0.046 of an acre of oats, 0.113 of an acre of hay, and 0.25 of an acre of pasture, or a total of 0.43 of an acre for a ewe and her lamb.

Number of ewes the farm will carry.

It has already been shown that the area required for the fixed stock, buildings, permanent pasture, etc., was 20 acres, thus leaving 60 acres of the farm for sheep, and since one ewe requires but 0.43 of an acre for her support, 60 acres will carry as many ewes as 0.43 is contained in 60, or 139, leaving off the fraction. It is assumed that three bucks will be needed for a flock of ewes of this size and that the bucks will require about the same feed as the ewes. It will therefore be safe to figure on a permanent flock of about 136 ewes and 3 bucks.

Acreage of crops to be grown for feed.

In replanning this farm as a sheep farm only such crops will be grown as the sheep and other live stock require. The acreages devoted to each of the crops of hay, pasture, oats, and corn are easily determined by multiplying the amount of each crop required for one ewe and her lamb, as shown in Table 2, by the total number of mature sheep kept on the place, or 139, and adding these results to the acreages required by the fixed stock as shown in Table 1. In the following table these calculations are made:

Table 3.—*Acreage required for the maintenance of 139 sheep and for the fixed stock.*

Kind of feed required.	Area required for 1 sheep	Area required for whole flock.	Area required for fixed stock.	Total area of each crop grown.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Corn	0.021	2.919	6.730	9.65
Oats	.046	6.394	1.030	7.42
Hay	.113	15.707	4.190	19.90
Pasture	.250	34.750	....	34.75
Total acreage required	....	....	....	71.72

The last column of the above table shows that to meet the requirements of the sheep and fixed stock on the farm there should be grown each year about 9½ acres of corn, 7½ acres of oats, 20 acres of hay, and 35 acres of pasture, or 72 acres in all, in addition to the 8 acres of land devoted to buildings, orchard, garden, and permanent pasture for cows and colts.

Rotation to be followed.

For all practical purposes, these 72 acres might be divided into four 18-acre fields and a four-year rotation adopted as follows: (1) Corn and oats (10 acres of corn, 8 acres of oats, and the whole field seeded to clover and timothy), (2) hay, (3) pasture, and (4) pasture. This rotation would supply each year 10 acres of corn, 8 acres of oats, 18 acres of hay, and 36 acres of pasture, which is practically what is needed by the stock kept.

This rotation calls for the seeding of clover in the corn at the last cultivation. Should the catch fail, a mixture of oats and field peas will be sown on the corn land the following spring and cut for hay. A mixture of clover and grasses should be seeded with the peas and oats to furnish pasture the following season.

Another rotation and arrangement of fields which would meet the needs of the sheep as regards crops and pasture would be as follows: (1) Nine acres of corn, (2) 9 acres of oats, (3) 9 acres of mixed clover hay, (4) 9 acres of mixed clover hay, and (5) four 9-acre fields of permanent or semipermanent pasture. The objection to this plan is the increased liability to stomach-worm diseases resulting from too long continued pasturing on the same fields.

Financial returns to be expected.

Having planned this farm as a sheep farm and having arranged to handle the flock by a method common on Illinois farms, the returns that may be expected from this type of farming may be considered. The sources of income and the gross returns that may be expected are about as follows:

136 lambs, at $4 each	$544.00
139 fleeces, at $1.50 each	208.50
2 colts, at $50 each	100.00
2 calves, at $5 each	10.00
Total returns	862.50

These returns are not particularly attractive, though nearly double what the farm is now paying. They hardly pay wages and interest on the investment. Had the owner not done some such preliminary figuring as here recorded, he might have gone into the sheep business somewhat along the usual lines, as outlined above, to his considerable disappointment.

Pasturage responsible for low returns.

An examination of the crop acreages required to support this flock of 139 sheep indicates the reasons for the comparatively low returns from this type of farming. Comparatively low-priced crops are grown. More than half the farm is in pasture. One-fourth of it is in hay. This is too large a proportion of high-priced land in cheap crops for profit.

There are other types of sheep farming much better adapted to this high-priced land. If a four-year rotation of corn, oats, hay, and pasture were adopted, only half the number of sheep kept, and the surplus grain and hay sold, the income would be increased from $862.50 to $1,045.

Again, if a four-year rotation of (1) corn, (2) corn, (3) oats, and (4) clover for hay were adopted, cowpeas sown in one cornfield at the time of planting, rape sown in the other at the time of laying by the corn, the first crop of clover cut for hay and the second used for pasture, and a good quality of western lambs bought in September at the average Chicago price for the past five years ($5.87) and pastured on the clover, cowpeas, rape, and standing corn, then fed clover hay and corn until February and sold at the average Chicago price for the past five years ($7.44), the income from the farm after deducting the usual expenses for freight, commission, etc., would be about $2,065. This increased return is due primarily to the fact that three-fourths of the farm each year is in grain, while during the latter part of the season practically the whole farm is used for pasture. This system of sheep farming, besides taking more than $2,500 extra capital for purchase of lambs, requires executive ability of a high order. It serves, however, to bring out the value of studying carefully the type of farming one is following for profit.

PLAN 5.—A HOG FARM.

The returns that may be expected on this 80-acre farm from making hogs the main source of income and by following one of the better plans of hog raising will now be considered.

Pasture crops desirable for hogs.

A bushel of corn fed to hogs on a dry lot or in a pen will produce on an average 10 pounds of pork. The same corn fed in connection with bluegrass, clover, or other suitable pasture will produce 30 per cent more pork; besides the hogs will be healthier, and there will be much less danger from disease in the pastured hogs.

In replanning the 80-acre farm here under consideration as a hog farm, therefore, suitable pasture crops will be provided throughout the season. An acre of clover pasture or its equivalent should carry, when at its best, 12 to 20 hogs. In the present plan it is assumed that each brood sow on the farm will have one litter of 6 pigs a season, probably in April, and that 15 bushels of corn will carry a sow a year or produce a pig weighing 200 pounds by December.

Cropping plan.

While a ewe and her lamb in the farm system presented in plan 4 will scarcely eat 130 pounds of grain a season, two pigs will eat 1,680 pounds of grain, or more than twelve times as much as the sheep. Sheep are primarily grass eaters. Hogs economically consume large quantities of grain. At the outset, then, it is seen that a hog farm must provide an abundance of grain, and in central Illinois that grain is corn.

In order, therefore, to grow as large an area of corn as possible and still follow a rotation of crops that will not permit of corn being planted on the same field oftener than two years in succession, with two years intervening before another corn crop is planted on the same field (for reasons that have been explained in plan 3), only one-half of the farm at most can be put into corn in a four-year rotation.

If there is set aside, therefore, as in all the plans heretofore considered, about 8 acres for the house, barn, orchard, garden, and permanent pasture for the cows, calves, and colts, there will remain 72 acres on which to grow crops for the fixed stock and the hogs.

This area may be divided into four fields of 18 acres each and a rotation followed of (1) corn, (2) corn, (3) oats, and (4) clover, exactly as discussed in plan 3. The important difference in the two plans is that instead of selling off the corn, as in plan 3, it will be fed on the place. The grain will be made into pork and the farm built up in productiveness considerably more rapidly than where all the corn is sold.

In the management of the fields the following general plan will be followed: One field of corn will be drilled in rows instead of checkrowed and with the corn will be planted about a peck of cowpeas. At the last cultivation of the corn a mixture of rye and rape will be sown in the corn to furnish additional green feed for the hogs in the fall. With the aid of movable fences this field of corn, cowpeas, rye, and rape will be harvested by the hogs themselves, the hogs being turned into the field early in September of each year.

The following year this field of corn, enriched by the planting of cowpeas, the pasturing off of the whole field with hogs, and the plowing under of the excess stubble and straw, will again be planted to corn. The third year the field will be seeded to oats and clover and the oats cut for grain. The fourth year the field will be in clover. A part of the clover will be pastured by hogs, part will be cut for seed, and a portion of the field plowed and seeded to a mixture of sorghum and rape for midsummer pasture, as outlined in detail farther along in this bulletin.

Conditions assumed.

In this plan, as in the others, it is assumed, in accordance with reasons previously stated, that by the use of 400 pounds of bone meal or its equivalent per acre on the corn and the growing of clover or an equivalent legume crop on the land once every three or four years in systematic rotation, the corn yield can be made to average on the farm in question 60 bushels and oats 40 bushels per acre.

For this type of farm also, as in previous plans, about 4 work mares, 2 cows, 2 colts, 2 calves, and in addition 1 boar will be kept. The grain required for this stock will be, as shown on page 11, 23,940 pounds. In order to reserve as much corn as possible for the hogs, this stock will be fed 680 bushels of oats—reserving 40 bushels for seed—which falls short 2,180 pounds of the required quantity. It will take 40 bushels of corn to make up this deficiency. In addition, 15 bushels of corn for the boar should be added.

Number of brood sows that can be kept.

Thirty-six acres of corn are grown in all and only 1 acre of it is required for seed and for extra feed for the fixed stock. It will therefore be safe to calculate roughly on about 35 acres of corn that may be fed to hogs. But it has been assumed that each brood sow and each of her 6 pigs will consume on the average 15 bushels of corn; therefore the total quantity consumed by 1 brood sow and litter—7 pigs in all—will be 105 bushels. At 60 bushels of corn per acre 105 bushels represents 1.75 acres of corn required for each brood sow and litter; 35 acres of corn land, then, will support 20 brood sows and their litters.

Pasture for hogs.

From the time clover pasture is ready in the spring until about June 1 the hogs will be pastured on 5 acres of an 18-acre field of clover fenced off with a temporary hog fence. Up to about June 1 the suckling pigs running with the sows do not need much pasture, and this 5 acres of young clover will furnish them and the sows all they will need. After removing the hogs from this 5 acres the clover will come on and later be cut for seed. About June 1 the hogs will all be transferred to 7 acres of clover adjacent, now in prime condition for pasture, and kept on it until about July 15.

To furnish fresh prime pasture for the hogs from about July 15, when the clover is past its prime, up to the time when the corn is ready to be hogged off, 6 acres of the 18-acre clover field will be plowed up about May 1 and planted in sorghum and rape. About July 15 the temporary fence next to this sorghum and rape pasture will be removed and the hogs given the run of the pasture they are already on and in addition the 6 acres of sorghum and rape. This will furnish ample green feed for the hogs until September 15, when all but the sows will be turned in on a portion of the 18-acre cornfield planted with peas and later sown to rye and rape.

The corn plant will have considerable feeding value for the hogs in September, but as the stalks become more woody the cowpeas, rye, and rape will furnish the necessary green feed and the corn and cowpeas will furnish the grain. As the hogs clean up one portion of the cornfield the portable fence will be moved and another portion added, and by the time the entire field is cleaned up the hogs will be ready for market.

In handling the clover crop for seed it is quite desirable that the clover be pastured off until about June 1 in central Illinois. The 5-acre field of clover that the hogs were pastured on earliest in the season has been handled so as to fulfill this condition, as shown in plan 2; therefore it may be cut for seed in late August. After the clover field has been cleared of the hogs which were turned into the cornfield and after the clover for seed has been harvested, the sows and boars may be given the run of the entire 18-acre field until cold weather or until the field is plowed in the fall for the next year's crop.

Financial returns to be expected.

The gross returns that may be expected from the 80-acre farm as here planned are about as follows:

120 hogs, 200 pounds each, at 5½ cents	$1,320
5 acres of clover seed, 15 bushels, at $6	90
2 colts, at $50 each	100
2 calves, at $5 each	10
Total gross returns	1,520

From this total must be deducted for the first few years about $175 each year for bone meal for the corn, leaving $1,340 to pay interest on the investment, wages, and expenses.

One of the interesting features of these results is that they are about $478, or 55 per cent, better than when the farm is handled in the ordinary way as a sheep farm. Another fact worth noticing is that while the returns for hogs are not much greater than where the farm is run in a similar way without hogs, all the corn is fed on the place. This practice, together with the practice of sowing cowpeas, rape, and rye in the corn and pasturing it off, will tend rapidly to build up the farm, so that in time even larger yields of crops than here assumed would be easily possible.

It will also be noticed that each field has a leguminous crop on it three out of the four years over which the rotation runs and that the field of corn that was hogged off has practically everything that was grown on the land left on it. The fertilizer bill may be reduced materially and at the same time the yields largely increased. The labor of gathering the corn is saved, and the experience of some of the most successful hog raisers demonstrates that there is not enough waste of grain in this method of harvesting to offset the wages for the necessary labor to gather the corn. Most of the labor on this farm can be performed by one man. The necessary extra equipment for hog raising on the farm is comparatively inexpensive. This type of farming is very attractive to a great many farmers because usually the hog requires less attention than most other farm animals.

For a detailed account of a successful 80-acre hog farm in Illinois on which the annual income available for general expenses, family income. etc.. was $2,284, see Farmers' Bulletin 272.

PLAN 6.—A DAIRY FARM.

General considerations on dairy farming.

With good cows and good management dairy farming is one of the most profitable types of stock farming; but with poor cows and ordinary management there is no money in dairying.

It is not profitable to pasture cows on high-priced land and sell butter for 25 cents a pound; it requires too much land for pasture, about 2 acres for each cow kept.

Feeding silage to dairy cows the year around has been found to be as satisfactory as regards milk yield and butter production as soiling in summer and silage in winter, and more convenient. By either of these methods many more cows can be kept on a farm of given size and more profit made than by the pasture system.

The most frequent sources of loss in the dairy business are poor cows, low crop yield, and inadequate rations. Home-grown feeds usually need to be supplemented with such feeds as cotton-seed meal, gluten feed, or oil meal in compounding rations for dairy cows which shall result in maximum milk and butter production.

With purchased feeds and the manure handled properly and put back on the land, dairy farming is one of the most certain methods known for building up a farm to a high state of productivity.

Conditions assumed.

It is assumed that if a man is going into dairying he will read up the business and make a thorough study of all the details of good cows, effective rations, proper herd management, suitable cropping systems, efficient methods of caring for and applying manure, and other like factors of importance. It is assumed that he will keep a herd of well-bred grade dairy cows, each of which will produce 6,000 pounds of milk or make 280 pounds of butter a year.

Since it is difficult to buy cows of this type whenever wanted, it is assumed that heifers will be raised for the purpose and that on the average there will be about one-fourth as many heifer yearlings and one-fourth as many heifer calves as there are milch cows, or in all one-half as many young stock as there are cows in the herd.

The problem is, How many cows with corresponding young stock will this farm of 80 acres support? To answer this it is first necessary to know how much fixed stock, like horses, colts, bulls, etc., will be kept and what this fixed stock, the young stock, and the dairy herd will be fed.

Fixed stock on dairy farm.

As in previous plans, it will be assumed that four brood mares will be kept on the place and two colts raised each season, and one bull kept for herd use.

Feeding system for stock.

Horses and colts.—The horses, as heretofore, will be fed an average of 15 pounds of corn and 10 pounds of clover hay daily, with all the cornstalks they will eat throughout the year. The colts will be fed 1½ pounds of clover hay for 120 days of the year and 1 pound of oats for about 300 days.

Cows.—The daily ration for the cows will average for the year as follows: 35 pounds of corn silage, 7 pounds of clover hay, 3 pounds of corn-and-cob meal, 2 pounds of oats, and 1 pound of cotton-seed meal. Corn stover in small amounts will be fed in addition.

The above combination of feeds will afford a well-balanced ration for cows giving 6,000 pounds of milk a year. All the grain will be grown on the place except the cotton-seed meal, or its equivalent, which will be bought. The grain will be mixed in about the proportions above indicated.

The quantity fed to one cow at any particular time will depend on the amount of milk the cow is giving. Roughly speaking, a pound of mixed grain will be fed for every 3 or 3½ pounds of milk given. Thus, if the cow is giving 30 pounds of milk a day 10 pounds of grain will be fed; if she gives only 15 pounds a day then only 5 pounds will be fed. The average for the whole year for one cow will be about as shown above.

Yearlings.—The yearlings from about May 1 to October 31, 184 days, will run at pasture and will receive on the average about 4½ pounds of hay daily in addition. It is estimated that each yearling will require on the average 1 acre of pasture for its support. From November 1 to April 30, 181 days, the yearlings will be fed 12 pounds of silage, 10 pounds of hay, and 2 pounds of corn-and-cob meal daily.

Calves.—The heifer calves that are kept will be allowed to run at pasture for about six months, or 180 days, of the year, and one-half acre of pasture will be allowed for each calf. They will be fed in addition about 5 pounds of hay daily throughout the year. Supplementing the hay for about three months they will receive 6 pounds of corn silage. One pound of corn-and-cob meal per head will be fed for about six months of each year, with a little oil meal in addition. About 2,000 pounds of skim milk will be fed each calf raised.

Bull.—The bull will be fed about 2 pounds of corn, 2 pounds of oats, a half pound of oil meal, 6 pounds of hay, and 25 pounds of silage a day.

Yields to be expected.

As in previous plans, average yields of 60 bushels of corn or 12 tons of silage, 40 bushels of oats, and 2 tons of hay per acre, when fairly started as a dairy farm, are assumed.

Acreage required for fixed stock and for buildings.

The grain and hay required for the horses, colts, and one bull, and the land required to grow these crops on, calculated from the feeding data and assumed yields per acre previously given, are as follows:

	Pounds.	Acres.
Corn:		
4 horses, 15 pounds, 365 days	21,900	
1 bull, 2 pounds, 365 days	730	
Total corn	22,630	or 6.735
Corn silage:		
1 bull, 25 pounds, 365 days	9,125	or .380
Oats:		
2 colts, 1 pound, 300 days	600	
1 bull, 2 pounds, 365 days	730	
Total oats	1,330	or 1.039
Hay:		
4 horses, 10 pounds, 365 days	14,600	
2 colts, 1½ pounds, 120 days	360	
1 bull, 6 pounds, 365 days	2,190	
Total hay	17,150	or 4.287
Total area required for fixed stock		12.441

From the above table it is seen that about 7.115 acres of corn, 1.039 acres of oats, and 4.287 acres of hay, or a total of 12.441 acres of land, will be required to grow crops for the fixed stock on the farm. To this must be added the land devoted to orchard, garden, buildings, and exercise lot for the cattle, or about 4 acres, making in all practically 17 acres. This subtracted from 80 acres leaves 63 acres on which to support the cows and young stock of the farm.

The number of stock that this area will support may next be determined.

Number of cows and young stock that can be kept.

To determine how many cows and young stock can be kept on this 63 acres it is first necessary to determine how much land is required to keep one cow and one-half as much young stock.

Feed consumed by one cow and corresponding young yearly.

Based on the rations already assumed, the quantity of feed required by one cow and corresponding young and the acreage required to grow the same on the farm are shown in the following table:

TABLE 4.—*Feed and acreage required for each cow and corresponding young.*

Kind of feed required.	Cow.[a]	Yearlings.[b]	Calves.[b]	Total feed required.	Area corresponding to total feed required.[c]
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Acres.*
Corn silage	12,775	543.0	135.0	13,453.0	0.561
Corn-and-cob meal	1,095	90.5	45.0	1,230.5	.293
Oats	730			730.0	.570
Clover hay	2,555	659.5	456.3	3,670.8	.918
Cotton-seed meal	365				
		Acre.	*Acre.*		
Pasturage		0.25	0.125		.375
					2.717

[a] The amount of each feed required for a cow per year is obtained by multiplying by 365 the average quantity of feed consumed daily, as shown on p. 28.

[b] The quantity of feed required by the yearlings and calves corresponding to one cow will be the quantity fed, as shown in the rations assumed, p. 28, multiplied by the number of days each feed is given, and the sum divided by 4, since there are only one-fourth as many yearlings and one-fourth as many calves as there are cows in the herd.

[c] The acreage of each crop required for one cow and corresponding young is determined by dividing the amount of feed required, as shown in column 4, by the yield per acre (as assumed on p. 28). It is estimated, also, that 1 bushel of corn will produce 70 pounds of corn-and-cob meal, or 4,200 pounds per acre.

The last column of the above table shows that the area of land required to grow the crops for the maintenance of one cow and corresponding young is 2.717 acres. On page 29 it was shown that 63 acres of the farm are available for cows and young stock. This area will therefore support 23.2 cows.

Omitting the fraction for the sake of convenience, it may be assumed that the farm will support about 23 cows and 12 head of young stock and that it will produce all the grain and hay required for them except about 4.25 tons of cotton-seed meal or oil meal, which must be purchased at a cost of about $32 per ton, or $136.

Acreage of crops required for feed.

With the data given in the last column of Table 4, which shows the acreage of each crop grown for feed required for the support of one cow and corresponding young, it will be easy to calculate the acreage required for the whole herd. Thus, in the case of corn silage, if 0.561 acre is required for 1 cow and young, 23 cows will require 12.9 acres.

The acreage thus obtained for all the crops grown for the herd of 23 cows, as well as the acreages of the different crops required for the fixed stock on the place, as shown on page 29, are given in the following table:

TABLE 5.—*Acreage of crops required to be grown on the farm.*

Kind of feed required.	Acreage required for each cow and corresponding young.	Acreage required for herd.	Acreage required for fixed stock.	Total acreage to be grown.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Corn silage	0.561	12.90	0.38	13.28
Corn for grain	.293	6.74	6.74	13.48
Oats	.570	13.11	1.04	14.15
Clover hay	.918	21.11	4.29	25.40
Pasture	.375	8.63	....	8.63
Total acreage	....	62.49	....	74.94

From the last column in the above table it will be seen that it will be necessary to grow on the farm each year for the herd and fixed stock 13.28 acres of corn for silage and 13.48 acres of corn for grain, or 26.76 acres of corn in all, 14.15 acres of oats, 25.4 acres of clover hay, and 8.63 acres of pasture.

Rotation to be followed.

For practical purposes of rotation it may be assumed that the acreages required for the different crops in round numbers are as follows: Corn, 27 acres; oats, 15 acres; hay, 25 acres; pasture, 9 acres; total, 76 acres. While on a dairy farm, where an abundance of stable manure is available, systematic rotation is not so essential as on a grain farm, yet rotation is always good farm practice. In the present instance it will be easy to fit the crops required to a four-year rotation. For this purpose the 76 acres may be divided into 4 fields of 19 acres each and the following cropping plan adopted on each field:

First year, 19 acres of corn, well manured.
Second year, 19 acres of oats, 4 acres cut for hay, whole field seeded down.
Third year, 19 acres of hay.
Fourth year, 19 acres—9 of pasture, 2 of hay, and 8 of corn.

This scheme would require movable fencing for the 9-acre pasture.

The crops in all the fields for the entire period of the rotation would be as shown in the following diagram:

Year	Field A (19 acres).	Field B (19 acres).	Field C (19 acres).	Field D (19 acres).
First	Corn.	Oats (4 acres cut for hay).	Hay.	9 acres of pasture. 2 acres of hay. 8 acres of corn.
Second	Oats (4 acres cut for hay).	Hay.	9 acres of pasture. 2 acres of hay. 8 acres of corn.	Corn.
Third	Hay.	9 acres of pasture. 2 acres of hay. 8 acres of corn.	Corn.	Oats (4 acres cut for hay).
Fourth	9 acres of pasture. 2 acres of hay. 8 acres of corn.	Corn.	Oats (4 acres cut for hay).	Hay.

Financial returns to be expected.

The gross returns that may be expected from a dairy farm on which 23 good cows are kept may now be estimated about as follows:

280 pounds of butter from each of 23 cows, at 25 cents	$1,610
100,000 pounds of skim milk, at 20 cents per hundredweight	200
16 calves, at $5 each	80
2 colts, at $50 each	100
Total gross income	1,990

From this gross income must be deducted $136 for cotton-seed meal or oil meal, leaving $1,854 as a gross return for the 80-acre dairy farm.

If milk were sold instead of butter and 4 cents a quart received, the returns would be about as follows:

61,000 quarts of milk, at 4 cents	$2,440
16 calves, at $5 each	80
2 colts, at $50 each	100
Total gross income	2,620

Deducting from this gross income $136 for concentrated feed, as before, leaves $2,484 to pay the expenses, interest, and labor of the farm. The calves that are kept will about offset the decreased value of the herd from year to year.

Labor item on a dairy farm.

While these returns for the dairy farm appear larger than for any other type of farming they are not so in reality, because it requires more labor on this type of farm than on any of the types previously considered. It will require the labor of the owner and one other man the year around, and during the growing season at least, or about seven months of the year, a second man will have to be employed. The cost of this extra labor to the owner will be at least $40 a month, including board, for each hired man, or about $760. This would reduce the gross income from the farm when butter is made from $1,854 to $1,094, and when milk is sold, from $2,484 to $1,724. At 5 cents a quart the gross income after deducting these same items would be $2,334.

Increased investment necessary in dairy farming.

A further item necessary to take into consideration in the dairy type of farming is the considerable increase in investment necessary. Each cow in the herd of the character here planned for costs at least $75. The cows, with the bull and young stock, represent an investment of at least $2,000. To this must be added a suitable stable and about two 90-ton silos, which would represent an investment of at least $1,500. In addition, a silage cutter, a milk separator, and other equipment would make in all an extra investment for dairy farming over the ordinary grain type of nearly $4,000. It is a system, however, in which the returns begin to come in at once and furnishes a cash income uniformly throughout the year.

Increased productiveness of a dairy farm.

While the labor bill and the investment are necessarily considerably increased in dairy farming, there is also a compensating feature. As all the crops grown on the farm are fed on the farm and additional grain bought and fed besides, the productiveness of the farm after the system has once fairly been put in operation will tend gradually to increase. In time every acre of land on the farm ought to be capable of producing an average of 90 bushels of corn or 3 tons of hay to the acre. This would permit an increase in the size of the herd, so that the profits would increase as the plan was continued.[a]

SUMMARY OF RETURNS FROM DIFFERENT TYPES OF FARMING.

A brief survey may now be taken of the differences in income which may be obtained from the same farm from the six different types of farming herein outlined. In all the types considered one man would be able to do practically all the work of the farm, except in rush seasons and in the case of dairy farming, and in one phase of sheep farming where two and sometimes three men would be required. Had the owner of the farm two or three sons to help him, more intensive types of farming than here outlined would have been planned.

The gross income from each of the different types of farming, after deducting the cost of fertilizers or feeding stuffs, is assembled below for comparison.

Farm as managed at present	$450
(1) Farm planned as a grain and hay farm, three-year rotation	1,149
(2) Farm planned as a grain and clover-seed farm	1,197
(3) Farm planned as a grain and hay farm, four-year rotation	1,280
(4) Farm planned as a sheep farm:	
(a) Pasture system	862
(b) Small flock	1,045
(c) Lamb feeding	2,065
(5) Farm planned as a hog and clover-seed farm	1,340
(6) Farm planned as a dairy farm:	
(a) Butter, sold at 25 cents (less extra labor)	1,094
(b) Milk, sold at 4 cents a quart (less extra labor)	1,724
(c) Milk, sold at 5 cents a quart (less extra labor)	2,334

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[a] For a detailed account of a 15-acre dairy farm in Pennsylvania which supported 17 dairy cows and returned a gross profit of $1,775, see Farmers' Bulletin 242.

An examination of the figures shows the returns for the different types to vary from $450 as now managed to $2,334 per annum in the case of dairy farming, indicating a wide variation in the returns possible from the same farm by different systems of farming. These data emphasize the importance of studying closely the organization of a farm and the plan on which it is operated. If a corn-and-oat rotation of crops brings in but $450 a year and by the use of clover and a little fertilizer the returns can be increased by $600 or $800 without additional machinery or hired help, then a revision of the system of farming would seem worth while. By combining some of the types here considered and by introducing other modifications the returns might be still further increased.

Generally speaking, grain farming with a rotation of crops and the intelligent use of fertilizers is about as profitable a type of farming as any of the ordinary forms of stock raising. The following facts, however, should be considered in this connection. The fertilizer bills in the grain and hay types of farming must be indefinitely continued, and as the years go by will probably have to be revised. Quite certainly lime will be needed in addition to the phosphates applied if the yields assumed are maintained. On the other hand, in the live-stock types of farming, particularly dairy farming, the fertilizer bills will grow less instead of increasing, while at the same time the land will be growing more productive, and instead of average yields of 60 bushels of corn and 2 tons of hay per acre considerably larger yields than these may be confidently expected.

PLANS GIVEN NOT MODEL PLANS.

The plans suggested in this bulletin are neither complete nor are they models to follow. Their purpose is to show primarily that the income from the same farm can be doubled, trebled, or often quadrupled by simply changing the system of farming and dropping the crops or practices that do not pay and substituting for them something that does pay.

The real purpose of the plans here made in some detail is to illustrate various ways of thinking about the farm when the time comes for replanning it for profit and of ways of going at the problem of estimating the stock that can be kept and the returns that may be expected to result from the adoption of a given type of farming.

It would be easy to modify in a hundred different ways each plan given by the introduction of other crops, by varying the combinations of crops, by emphasizing the poultry industry or the orchard, by combining hogs with dairy cows, and so on. The plans given in this bulletin, however, will serve their purpose if they suggest ways of looking at the problem and estimating returns.

THE PROBLEM OF REPLANNING A FARM.

The reader who may be led by the preceding pages to replan his own farm will quickly learn how limited is the reliable available information on any given phase of farming and how necessary is a broad fund of agricultural knowledge in successfully replanning a farm.

If he relies for the purpose on what data he has accumulated on his own farm, he may be surprised to find out how limited such data are and that he may not even know how much grain and hay it takes to keep a horse or a cow a year, although he may have fed both all his life. He may not know just when or just how long a field of peas and oats planted together would be available for sheep or hog pasture. He may not know the average yields of different crops that he can grow on different fields, or how those yields might be increased by the use of a little commercial fertilizer of the right kind properly applied or by rotation of crops. He may even have to go outside of himself to establish a standard as to what good farming really is and what results ought to be obtained from good farming.

If these gaps in his knowledge be made apparent through his undertaking to replan his farm and he be led thereby to observe more closely his farm operations, as well as those of his neighbors, and to read more extensively agricultural papers, bulletins, books, and reports, one of the first aims of this paper will have been accomplished.

WHY LOW RETURNS ARE REALIZED FROM SOME FARMS.

Many a farmer fails to get adequate returns from his farm because he stays at home too closely, puts in too many hours a day following the plow, and does not often enough visit good farmers in his neighborhood or other sections of the country where good farming is done. Furthermore, a man physically exhausted from a long, hard day's work is in no condition to follow and get much out of the literature of his business as reported in farm papers, agricultural bulletins, reports, and books, and without the advantage of all the information available from every possible source he will find awkward situations when he comes to replan his farm for profit.

Success in farming calls for the very best effort in a man along all lines. That best effort is called for in replanning a farm for profit. The farmer who is dissatisfied with his income from the farm needs to think seriously as to whether or not his farm is planned right for the largest returns, remembering that good farming calls for keeping up the productiveness of the farm while getting maximum crops economically from the soil.

SUMMARY.

(1) Habit frequently continues a type of farming in a community long after that type has become unprofitable.

(2) Changes in the farm system are often deferred (1) because of lack of knowledge of how to replan the farm, (2) because of lack of funds in carrying out new plans, (3) because new fences, buildings, or equipment are called for in the new plan, and (4) because a change frequently requires a readjustment of many of the usual ways of thinking and doing.

(3) In replanning the farm, help may be obtained from visits to successful farms, from farm literature, agricultural papers, the State experiment stations, the agricultural colleges, the United States Department of Agriculture, and from agricultural experts.

(4) The farm can be as successfully planned as other businesses are, provided the plans are made to cover average conditions over a period of years.

(5) Profitable farming results from good farm plans comprehending every feature of the farm carefully coordinated and effectually carried out.

(6) A good farm plan provides for (1) a reasonable reward for the capital and labor invested and (2) the maintenance or increase of soil fertility, and (3) it must be within the comprehension and ability of the owner to carry out.

(7) The income from the same farm can often be doubled or trebled without increased expense by adopting a system of farming suited to the land, the locality, and the owner.

(8) The successful replanning of a farm rests on a comprehensive knowledge of agriculture gained by experience and by familiarity with what is being accomplished by others along agricultural lines, either as observed by personal visits or as recorded in the literature of agriculture.

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DRAINAGE OF IRRIGATED LANDS.

BY

CHARLES F. BROWN,

Drainage Engineer, Drainage Investigations,
Office of Experiment Stations.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., May 10, 1909.

Sir: I have the honor to transmit herewith a report prepared by Charles F. Brown, Drainage Engineer, under the direction of C. G. Elliott, Chief of Drainage Investigations of this Office, upon the drainage of irrigated lands which have been seriously injured or rendered wholly unproductive by the seepage of irrigation water or by the rise of alkali, or by both combined.

While the report gives the details of experiments in the State of Utah only, the localities are so widely separated and cover such a variety of soils and conditions that the lands are fairly representative of irrigated lands elsewhere which require drainage. The work was conducted by Drainage Investigations of this Office in cooperation with the Utah Agricultural Experiment Station.

It is estimated that not less than 150,000 acres of irrigated land in Utah have been ruined or seriously injured by seepage or alkali, and will require drainage in order to restore them to a productive state. In all other irrigated States from 10 to 20 per cent of the land which has been under irrigation for ten years or more requires drainage. This report not only describes the condition of the land, the details of its draining, and the results which were obtained in particular cases, but gives carefully drawn deductions from the experiments, together with directions for draining lands which have become too wet or too alkaline under the ordinary methods of irrigation for profitable cultivation. Methods of draining are not so well established for irrigated land as for land in humid areas, which fact suggests the propriety of describing methods that have been tested in specific cases.

Since the matter contained in this report relates to farm drainage in the arid States, and thus supplements Farmers' Bulletin 18, Drainage of Farm Lands, I recommend its publication as a Farmers' Bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
Cache County investigations 7
  Hyde Park experiment 7
    Plans and construction 7
    Cost 10
    Results 10
    Obstruction of tile by roots 11
Boxelder County investigations 11
  Garland experiment 12
    Plans and construction 13
    Cost 15
    Results 15
  Point Lookout experiment 15
    Construction and cost 16
    Results 17
Investigations in Weber and Davis counties 18
  Roy experiment 18
    Plans and construction 19
    Cost 20
    Results 20
  Ogden experiment 20
    Plans and construction 21
    Cost 21
    Results 22
  Clearfield experiment 22
    Field construction 24
    Beneficial results 24
  Syracuse experiment 25
    Results 25
Emery County investigations 25
  Huntington experiment 26
    Plans and construction 28
    Cost 29
    Extensions 30
Sevier County investigations 32
  Richfield experiment 32
    Plans and construction 33
    Cost 34
    Results 34
Washington County experiment 35
  Experimental tract 36
    Plans and construction 37
    Cost 38
    Results 39

Washington County experiment—Continued.
Experimental tract—Continued.

Page.
Extensions ... 39
Cost ... 40
Results ... 40
Proposed extensions ... 41
Estimated cost ... 42
Drains in the town of St. George ... 43
Drainage of irrigated lands in other States ... 44
Principles and practice ... 45
Lands needing drainage ... 45
Alkali and ground water ... 45
Plans for drainage ... 47
Field construction ... 49
Subsequent care necessary ... 51
Summary ... 51

ILLUSTRATIONS.

Page.
Fig. 1. Map of Utah, showing locations of drainage experiments ... 6
2. Map of field drainage, Hyde Park, Utah ... 8
3. Map of field drainage, Garland, Utah ... 12
4. (*a*) Method of grading trench; (*b*) measuring bar for setting guide stakes and grading ... 13
5. Sand trap and surface inlet ... 14
6. Plan of draining Getz field, Point Lookout, Utah ... 16
7. Plan of draining Hobson field, Roy, Utah ... 19
8. Plan of draining Wasatch Orchard Company's field, Ogden, Utah ... 21
9. Plan of draining Clearfield Orchard Company's orchard, Clearfield, Utah ... 23
10. Plan of draining Walker and Williams fields, Syracuse, Utah ... 24
11. Field contour map showing location of Geary farm ... 26
12. Plan of draining Geary farm, Huntington, Utah ... 27
13. (*a*) Box drain for firm ground; (*b*) box drain for soft ground ... 28
14. (*a*) Relief well on Geary farm, Huntington, Utah; (*b*) method of laying box drain, with gravel filling and plank sheathing, through soft ground ... 29
15. Plan of draining Gardner and Ogden fields, Richfield, Utah ... 33
16. Map showing proposed drainage of Washington field and also location of experimental tract, St. George, Utah ... 37
17. Plan of draining experimental tract, St. George, Utah ... 38
18. Proposed trench and drains for Washington field, St. George, Utah: (*a*) Cross-section of open trench for main drain; (*b*) detail of box drain for covered main drain; (*c*) cross-sections of box drains for branches I, II, and III ... 41
19. Town drainage map, St. George, Utah ... 43

DRAINAGE OF IRRIGATED LANDS.

INTRODUCTION.

The general need for drainage of irrigated lands has increased rapidly during the last twenty years. The most productive lands of these regions and those which were first brought under cultivation are, in many instances, now abandoned or fit only for wet pasturage. In Utah alone there are approximately 200,000 acres of irrigated lands needing drainage. Salt Lake Valley has about 34,000 acres of such lands, and several other valleys from 10,000 to 30,000 acres each. There are several localities in which, of the total irrigated lands, 50 per cent are in such condition. California, Colorado, Washington, Montana, and Wyoming are likewise affected, more or less, and in time all of the newly irrigated lands will have their problems of drainage. It naturally devolves upon the holders of such lands to reclaim them. To the end of developing the best methods for accomplishing the reclamation of such lands the Office of Experiment Stations has conducted drainage investigations in Utah, California, Oregon, Washington, Wyoming, Colorado, and Nebraska, with results which justify the conclusion that there is scarcely any land in the irrigated region which formerly produced paying crops, and later became affected by excess of water or alkali, that can not be profitably reclaimed, provided the work is correctly planned and carried out. These results also point to the possibility of reclaiming many virgin lands containing an excess of alkaline salts.

This bulletin, while it applies to all irrigated lands and contains some data obtained in investigations in other States, is based upon experimental work done in Utah. For the localities in which the experiments were performed, see the map of Utah (fig. 1). The drainage investigations of the Office were begun in the State during the summer of 1904 in cooperation with the Utah Agricultural Experiment Station. Since then the work has been carried on with a fund provided jointly by the State legislature and the Office of Experiment Stations, the Utah station acting for the State.[a]

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[a] For further details of the Utah work see Utah Sta. Bul. 99.

The individual landowners have in every case cooperated with the State and Federal agents in carrying out the work. The attitude of most of them has naturally been one of skepticism as to the success

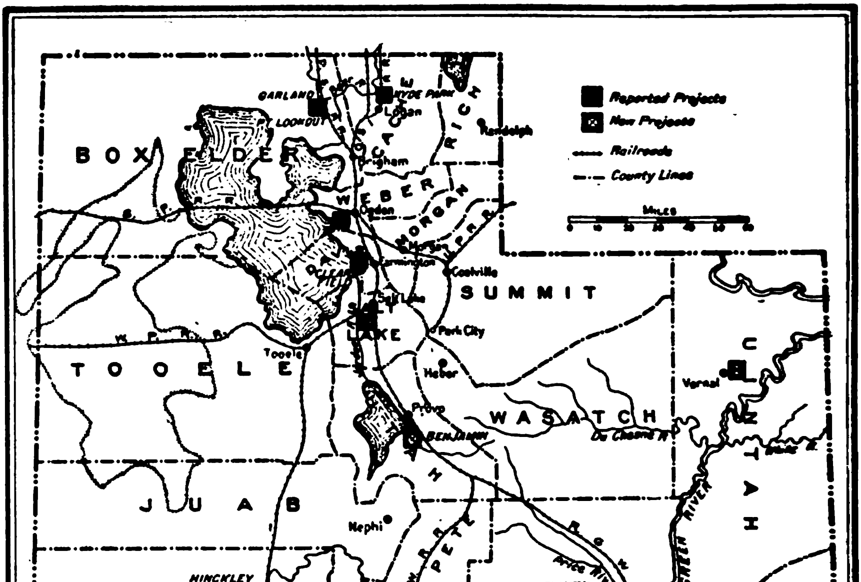


FIG. 1.—Map of Utah, showing locations of drainage experiments.

which could be obtained, and they have been convinced of the feasibility and financial advantage of the methods proposed only by actual successful demonstrations of results on a commercial scale. In one case the county interested also cooperated in the expense.

CACHE COUNTY INVESTIGATIONS.

HYDE PARK EXPERIMENT.

This experiment was made on lands just south of Hyde Park, in a belt of 2,000 acres, between that town and Logan, which was badly affected by the rise of ground water. The soil is a black loam underlain by yellow clay, both of which are of an open nature and permit the passage of water freely. These lands were among the first brought under cultivation in this neighborhood and originally produced abundant crops. After some twenty years of satisfactory cultivation, a rise of ground water resulted from the irrigation of the higher lands which had in the meantime been brought under cultivation. The amount of seepage gradually increased, and lands which had been tillable for cereals and root crops became unsuited for such crops and were planted to grasses for hay. The tame grasses were driven out in a few years and water grasses of little value prevailed. In the beginning the areas affected were small, but they continued to spread and creep up to higher levels in the typical manner, until few farms were unaffected.

It was noticed that when the fields upon the upper bench, one-half to three-quarters of a mile distant, were irrigated the soil water appeared at the lower levels about thirty-six hours later. This indicated that the primary cause of the wet condition of the lower lands was seepage from the more elevated fields. Observations later established the fact that the water passed through the soil along the line of greatest surface slope until it reached the lower sections, where it accumulated. Owing to the soil structure the ground water passed more readily through some parts than others, thus giving the water an uneven distribution, causing wet spots rather than a uniformly saturated condition of fields, as ordinarily might be expected.

Work was begun at Hyde Park during the summer of 1904.

Plans and Construction.

For the purpose of showing the surface slopes on the following maps (fig. 2 and others) contour lines are employed. Contours are lines running through points of equal elevation, corresponding to successive shore lines which would be formed if a tract could be covered with water and the water level then lowered a foot at a time, allowing sufficient intervals of time between reductions to mark shore lines. These lines are determined by the level and are marked with the elevations relative to a determined datum.

The experimental area is that within the shaded belt. The drains outside this area were laid by the owners in accordance with plans and survey made by the Office of Experiment Stations. The branch of 8-inch and 6-inch tile laid along the upper edge of the wet land was designed to intercept the seepage from the lands above, and the 5-inch lower branch was planned to furnish an outlet to the seepage which passed the upper line. The average depths and sizes are given on the

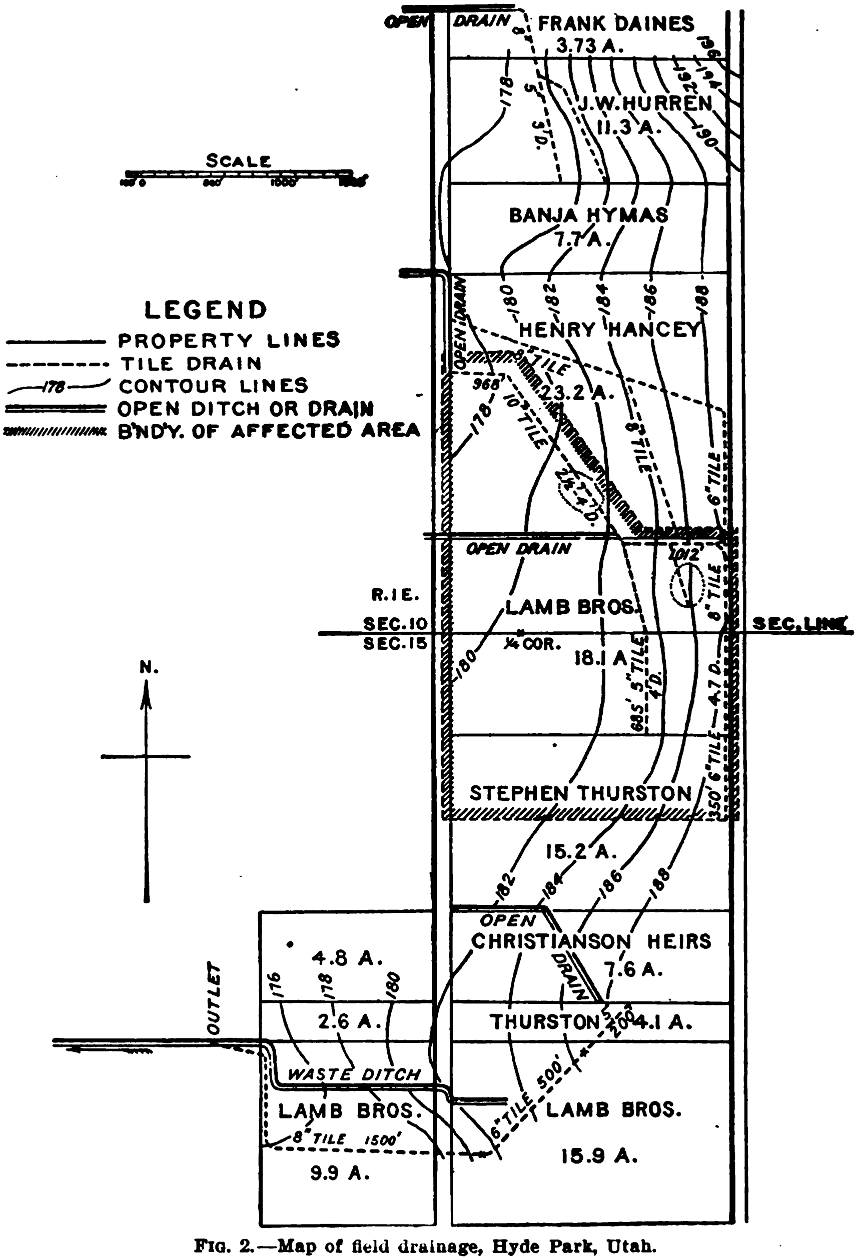


FIG. 2.—Map of field drainage, Hyde Park, Utah.

map. These two lines discharged at their junction into an open ditch which gave much trouble on account of the banks caving in. Owing to the obstructions in the ditch the tile lines were kept full of backwater and consequently did not work properly. During the season of 1905 the 10-inch outlet through Hancey's field was laid. An illustration of the rise of water in spots is here shown in the two areas inclosed by dotted lines. The one in the Hancey field remained wet until the 10-inch line was laid through it, in spite of the fact that it was almost surrounded by lines of tile laid the year before. The spot in the Lamb Brothers' field is still wet and needs a branch line cutting through it.

The construction work, except surveying, was done by the farmers. Preparatory to laying out the lines of tile a preliminary level survey was made. This work was simple, consisting of levels at important points, and was made by two men in an hour or two. With the figures thus secured, it was easy to stake the lines with assurance that the depths and grades would be satisfactory. In this and following work two sets of stakes were driven at 50-foot intervals and 6 inches from the edge of the trench. The stake from which the elevations and profile were determined was driven until the top was flush with the surface. The other, a 1-inch by 4-inch by 18-inch stake on which the station number and cut were marked, was set near the grade stake as a guide. Grade was obtained at each station by measurement and between stations by the flow of water. The grade of the bottom made in this way was more or less irregular, but on the whole fairly good, as indicated by the flowing water. The necessity of properly grading the bottoms of the trenches was not appreciated by some of the farmers who put in drains on their own account, and as a result in some cases it was necessary to dig up and relay the tile, because they had become obstructed in low places by sand and sediment. The soil generally was firm and would stand well after trenches were opened, so that the water method of grading, with measurements every 50 feet, was sufficient if followed with care. When the trenches were dug it was noticed that the water entered freely through crevices and channels in streams, some as large as a lead pencil. The subsoil, a granular clay, is somewhat stratified and sufficiently open to admit the moderately free passage of water. On the whole it may be regarded as a soil for which tile or other underdrains are suited, as there is sufficient clay to keep the soil compact. A few sand pockets and other soft spots were encountered in parts of the fields outside of the experimental tract, and boards should have been laid under the tile in these places to insure proper alignment. Neglect to take these precautions resulted in failure in one place. The tile were laid by a man in the trench, and were blinded or carefully covered with a foot of soil as soon as laid. This is necessary to prevent displacement when filling the trenches by plowing, as is usually done.

Cost.

Excavating the trenches, as reported by Messrs. Lamb and Hancey, who did the work, cost 40 cents per rod for the smaller and 52 cents for the larger trenches, where the depth did not exceed 4 feet.

The following table of costs is given for the experimental drains and charged to the experimental tract, which is approximately 31.5 acres. The cost per acre was greater than if the whole tract which was actively affected by the drains were considered. As shown later, the effects of these lines reach to one-quarter of a mile down the slope.

Tile:		
1,000 feet of 10-inch tile, at $182.50 per thousand feet	$182.50	
1,012 feet of 8-inch tile, at $120 per thousand feet	121.44	
330 feet of 6-inch tile, at $60 per thousand feet	19.80	
650 feet of 5-inch tile, at $58 per thousand feet	37.70	
2 6-inch on 8-inch wyes, at 72 cents	1.44	
		$362.88
Hauling, digging, and laying:		
Hauling tile, 30 tons 1¼ miles, at 30 cents per ton mile	13.50	
Digging 134 rods, at 52 cents per rod	69.68	
Digging 42 rods, at 40 cents per rod	16.80	
Laying tile	18.75	
Filling trench	10.00	
		128.73
Total cost		491.61

The average cost per acre was $15.60. The above costs were based on ten working hours per day, with labor at $2 per day, tile layers $2.50 per day, and man with team $3 per day.

Results.

The land has been well drained, with the exception of the small spot in the Lamb Brothers' field mentioned above, and is yielding abundant crops. The owners reported yields in 1905–6 which were high for land in the best possible condition. Since drainage, 50 bushels of wheat and 100 bushels of oats per acre have been grown on the reclaimed land. The yield of beets for 1906, on drained land, was 18 tons per acre. The draining of this strip, only one-quarter of a mile wide, has made it possible to break the sod on an equal strip below and to again grow crops there. With the exception of the farmers who were interested in this work but very few are attempting drainage in other fields.

Obstruction of Tile by Roots.

It has long been known that the roots of certain water-loving trees, such as willows, would enter covered drains through the joints and small openings and branch into water roots many feet long, so numerous and close together as to fill the tile, thus obstructing the flow of water. It was also learned by these investigations that alfalfa roots were equally troublesome after a few years. During the fall of 1907 the ground water rose to the surface over the drains in Hancey's and Lamb's fields. The beets which were planted in the fields turned yellow and the ground became so soft that harvesting the crop in that condition was out of the question. Upon removing some of the tiles it was found that they were almost completely obstructed by beet roots. About half of the tile was removed, after which the balance was cleared of roots, and in a short time the ground was dry. During the last season, with the beets removed from about 2 feet on each side of the trench, no trouble resulted.

BOXELDER COUNTY INVESTIGATIONS.

The large valley in which this work was done is irrigated by the Bear River canals. The valley lands have varying slopes, from heavy ones near the foothills down to very light slopes on some of the lower lands. The soils also vary from sandy loams to clay, and are generally very deep, as shown by the cuts of the Bear and Malade rivers. The depths of these cuts are from 50 to 100 feet, and they were supposed to afford excellent drainage. Nevertheless, many of the lower lands became affected by the rise of ground water and alkali soon after the beginning of irrigation. An unsuccessful attempt was made to drain portions of the model farm at Corinne, but not even the locations of the lines are now known. This failure discouraged many, and thousands of acres were abandoned, seemingly without an effort to stay the spread of alkali. The northern portions were considered the only safe lands on the west side.

A survey of the valley, made by the Bureau of Soils in 1904, showed that the lands between the rivers and those above Garland on the west side were the only portions not affected. The area affected continued to increase, and investigations in 1906 showed that the acreage of affected lands in these favored districts had reached approximately 7,000 acres. Even in Riverside, which had been considered perfectly safe from all danger of injury by seepage water or alkali, there was a fine farm of 100 acres seriously needing drainage and showing unmistakable signs of alkali. It was under such conditions as these that the investigations were begun in this valley in May, 1906.

GARLAND EXPERIMENT.

This tract lies 2 miles north of Garland and one-half mile west of the Malade River, the surface of which is 50 feet lower than the tract. The west branch of the Bear River Canal lies one-half mile west of the affected land. The soil is a clay loam underlain by

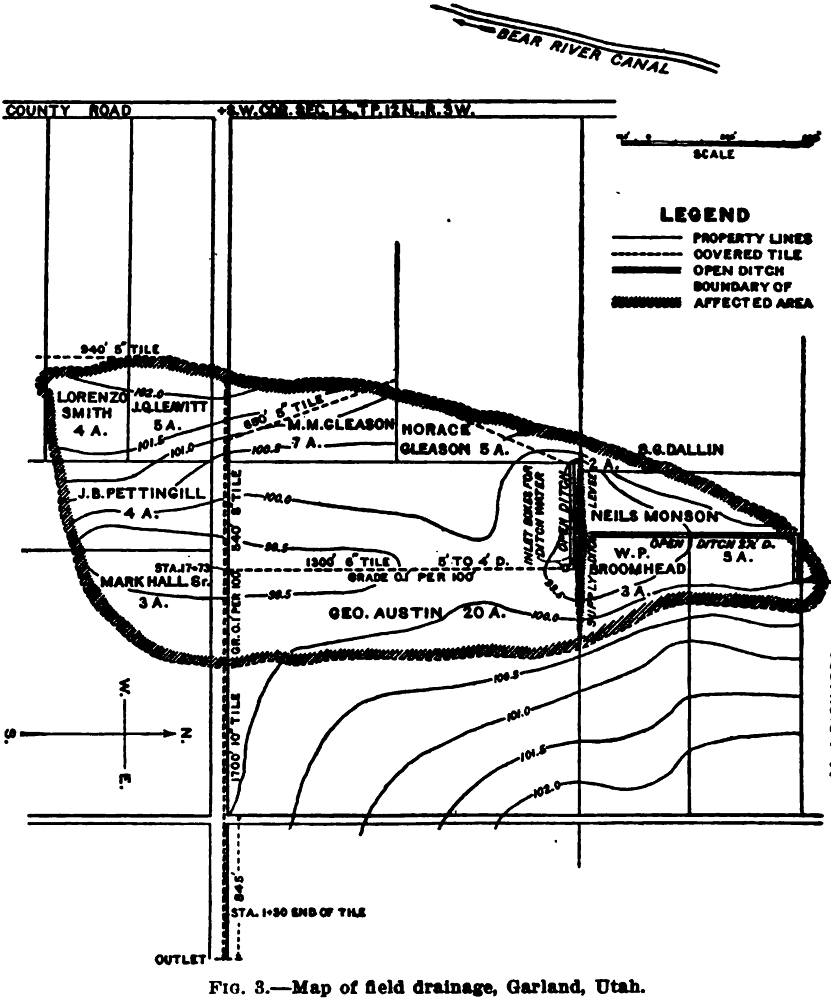


FIG. 3.—Map of field drainage, Garland, Utah.

separate strata of sand and clay and pockets of sand. The affected portion (see fig. 3) contains 60 acres, and is a part of a flat depression extending from Garland to Riverside. The lands between this tract and the canal are sandy and require considerable water.

The source of the water was seepage from irrigation and the canal. Snow and rain water, held by a levee, were also responsible. In its development this particular case of water-logging and alkali was similar to other cases, and the condition of the land was thought at first to be desirable. The trouble began with a season of subirrigation, and the crops grown were record breakers. This luxuriant growth of crops usually precedes failure due to alkali, and there is little doubt that this tract would have become totally unproductive had not the cause been removed. In this case cropping was delayed for several weeks during the next season because of wetness. Later, beets were planted on most of the land; small spots failed to produce a stand; and subsequently several acres of the beets were drowned by spring rains. It was at this stage that plans for cooperative drainage were begun by the owners. Later the Office of Experiment Stations furnished some assistance, mainly in planning and superintending the work. Eleven farmers, owning lands which would be benefited, cooperated, apportioning the cost according to the areas of their wet lands.

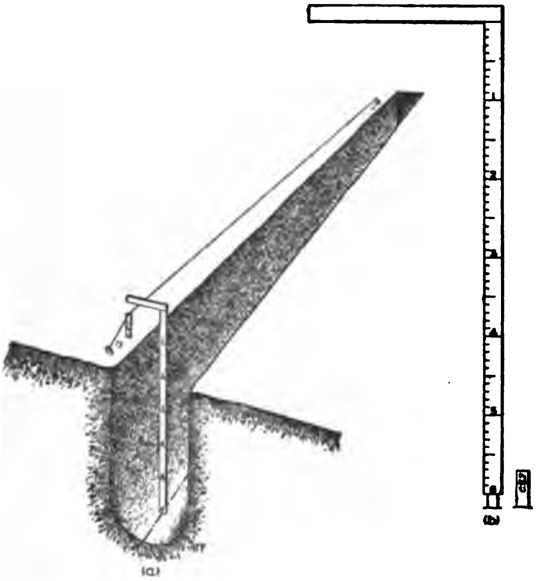


FIG. 4.—(*a*) Method of grading trench; (*b*) measuring bar for setting guide stakes and grading.

Plans and Construction.

The land within the shaded belt (see fig. 3) shows the wet portion. From the single dotted lines, representing drains, it will be seen that both the intercepting and outlet methods were used in laying out the system. A portion of the water was lateral seepage through the porous lands above, which the upper lines served to intercept, while the lower lines provided an outlet for the lowest portions of the tract. During construction small springs were encountered in the trenches in which the water seemed to come from a lower porous stratum.

The matter of properly setting guides for grading the bottom of the trench gave some trouble and, in one instance, resulted in laying the 6-inch line through the Austin field 1 foot above grade, beginning about 100 feet north of the junction with the 10-inch main. This mistake has not yet been rectified. With the hope of making the method for grading clearer, the following explanation is offered: Two sets of stakes are used, as at Hyde Park, one a grade stake driven to the surface of the ground, from which the levels are taken, and the other a guide stake, on which the cut for that particular station is marked. These stakes should be set 1 foot from the edge of the trench. The long one should be long enough to be driven about 1 foot into the ground and leave about 2 feet above ground. Figure 4*a* shows the stakes in position, with a wire or string stretched across the tops of the guide stakes parallel to and just 6 feet above grade. The guide stakes have been driven until the tops are above the grade stakes an amount equal to the length of the measuring bar minus the cut at the station. If the measuring bar be graduated, as shown, from the top down, the guide stakes may be set by driving them down to a level of the cut reading on the rod when the rod rests on the grade stake, as in figure 4*b*. With the rod held vertically, the lower end is at true grade when the horizontal arm touches the wire.

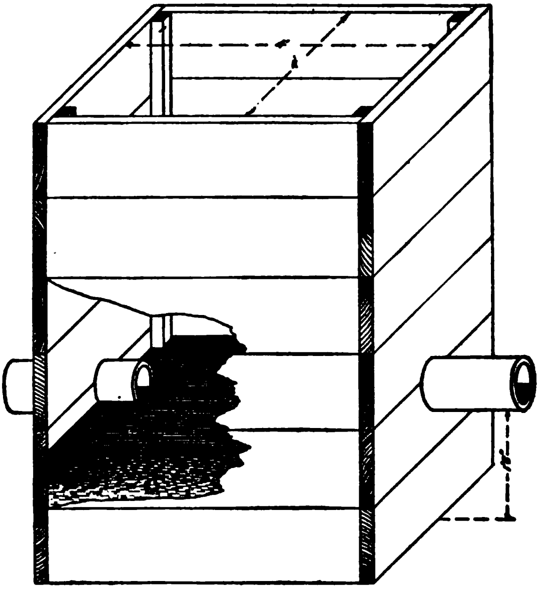


FIG. 5.—Sand trap and surface inlet.

Construction difficulties were encountered when the work reached the wetter portions of the field. The usual soft spots were encountered, with water entering in relatively large streams. A firm foundation for the tile was necessary, so some gravel was thrown in. Later experiments proved that 1-inch by 6-inch boards were more convenient. Fine sand and silt gave considerable trouble by flowing in at the joints and settling in the tile, and to prevent this a few joints were wrapped with tarred paper. Sand and gravel would have stopped this and been better adapted to the needs. Later, a sand trap, shown in figure 5, was put in at the junction of the south branch and the main. This box was made 4 feet by 4 feet inside and extended 18 inches below the grade of the tile. A box was also set in just above the lower place of trouble, where flushing water was turned in to clean out the tile. A large portion of the sediment settled in the larger tile below. Another sand trap should have been put in at the junction of the 8-inch and 10-inch tile on the main line.

Cost.

Tile:		
1,700 feet of 10-inch tile, at $181.10 per thousand feet	$307.87	
540 feet of 8-inch tile, at $125 per thousand feet	67.50	
1,300 feet of 6-inch tile, at $74 per thousand feet	96.20	
2,775 feet of 5-inch tile, at $50 per thousand feet	138.75	
		$610.32
Labor:		
Labor for 384 rods, at $1 per rod	384.00	
Open ditch work	18.00	
		402.00
Total cost		1,012.32

The average cost per acre was $16.87, including the 1,700 feet of 10-inch outlet. Wages were $2 to $2.50 per day of nine hours.

Results.

The resulting improvement in this tract, even before the system was entirely finished, was very marked. The next season this land was planted as early as the higher lands and produced just as good crops. Not a trace of alkali showed, where it was plainly evident the year before. There is no question that these 60 acres, and probably more, would have become entirely unproductive within a few years, but with drainage they are producing as well as those unaffected.

POINT LOOKOUT EXPERIMENT.

This tract is located about 5 miles southwest of Garland and 3½ miles west of Tremonton, on the county road, and is fairly typical of the majority of lands in this valley which have lost their productivity of late years on account of seepage water and alkali accumulations. The soil is a clay loam with a mushy water-bearing stratum, about 12 inches in thickness, between 4 and 6 feet below the surface. The tract was brought under cultivation in 1897. The first crop was 42 bushels of wheat per acre, and those following were good until 1902. Since then the tract has not paid expenses. Investigations were begun here in September, 1906, at which time there were large dark-brown alkaline spots throughout the field, on which nothing grew. Alkali was evident in other spots from the familiar white efflorescence.

Plans were made after careful preliminary surveys of surface slopes and examination of subsoil conditions (fig. 6). The intercepting method was used principally, but some parallel lines through the worst portion seemed necessary, as need for considerable leaching for the removal of alkali was expected. The tile were laid from 4 to 5 feet deep, cutting through the close subsoil into the more open water-bearing stratum. For field map and system of drains see figure 6.

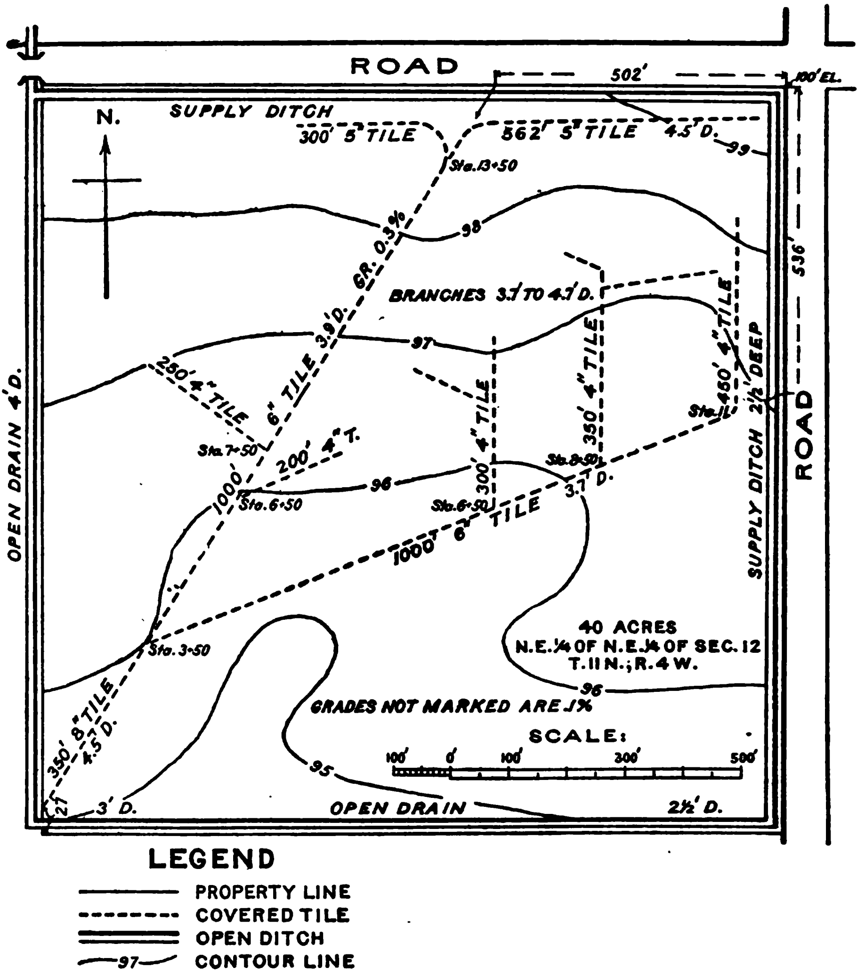


FIG. 6.—Plan of draining Getz field, Point Lookout, Utah.

Construction and Cost.

The most important lesson to be learned from the field construction is that the cost of such work can be reduced one-third to one-half by experienced laborers. The tools used for digging and grading were ditching spades and tile scoops. The work was done by experienced farmers during December and January, 1906–7.

Tile:		
2,100 feet of 4-inch tile, at $40.15 per thousand feet	$84.32	
812 feet of 5-inch tile, at $55.22 per thousand feet	44.84	
2,050 feet of 6-inch tile, at $7.85 per thousand feet	161.64	
350 feet of 8-inch tile, at $133.35 per thousand feet	46.67	
Extras, wyes and tees	3.41	
Total		$340.88
Digging and laying:		
85 days, at $2 per day of 9 hours	170.00	
Hauling tile ½ mile, 7 days, man and team, at $3 per day, 70 cents per ton	21.00	
Filling trench, man and team, 3 days, at $3 per day	9.00	
Total		200.00
Total cost		540.88

The average cost per acre was $13.52. The labor cost was approximately 4 cents per linear foot, or 65 cents per rod.

Results.

The land has been thoroughly drained excepting a few acres in the southeast corner, which remained a little damp after the wet spring of 1907. That spring was an unusually wet one, but this farm as a whole was in better shape for early spring work than the best lands in the same neighborhood. The wet spot above mentioned was probably caused by lateral seepage from the land on the east. Notes taken during the spring and summer show that the tract responded to drainage remarkably well. Early in the spring it showed improvement, and to all appearances was free from alkali. Later it was planted to oats, continuing to improve and yielding 35 bushels of oats per acre. No signs of the alkali spots have been observed, and as a consequence it has attracted considerable attention. For the season of 1908 the Getz tract produced 45 bushels of oats per acre and an excellent stand of young alfalfa.

The influence of the experiment has already been felt. Early in the spring of 1907 other farmers came to see it, and straightway ordered tile. They received some assistance in locating and laying out lines. Mr. P. A. Hansen, of Elwood, laid some tile through a small orchard and on the advice of this Office strung the tile with a galvanized wire, by which a cable and root cutter can be worked if roots cause trouble, as they are expected to do. A steam traction ditcher is now in use in this district and a tile factory is in operation.

INVESTIGATIONS IN WEBER AND DAVIS COUNTIES.

The work done in these counties was with the seepage and alkali conditions on the bench lands between Ogden and Layton. The soil has probably been brought down by the Weber River, and is classified, in a survey by the Bureau of Soils, as a fine sandy loam. The higher portions through which the canal runs, and which are also irrigated, contain considerable gravelly soil. Until recently this section, called the " Sand Ridge," was not irrigated. Fall wheat was grown successfully without irrigation. The soil and climate are particularly adapted to vegetable gardening and fruit. Bare land in good condition is worth $150 per acre and orchard land much more. Several years ago some seepage began to show on the lower slopes. The number of places affected increased, and they were not confined to any particular slope or level. The total area of such lands grew rapidly, and alkali made its appearance. In 1906 the area affected was estimated at 2,000 acres, and has increased since then.

ROY EXPERIMENT.

This experiment was made on the J. H. Hobson farm, 2 miles west of the Oregon Short Line Railroad station at Roy. The farm lies on a series of narrow benches, having a difference of elevation of from 6 to 10 feet. The soil is a clay loam with sandy spots, underlain by a tough clay subsoil to a depth of 4 feet, beneath which lies a 12-inch stratum of water-bearing sand. There were several spots found where the sand was continuous from the surface to the water-bearing sand below. The strata are not in a blanket form at an even depth from the surface, but horizontal and at different depths on the various benches. The soil seemed to have formed over the edges of the benches compactly enough to hold the water in the sand and make it rise to the surface above. Some hardpan was encountered at a depth of 4 feet near the sand trap (fig. 7), at the junction of the main and the west 5-inch line. It is the typical calcium carbonate, lake shore hardpan, which is readily penetrated by roots and is fairly pervious to water.

Seepage water had appeared at the bottom of the steeper slopes and spread in places 40 rods or more down the slope, bringing an accumulation of alkali. This farm had been known generally for some time as one badly affected with alkali. It had come into the present owner's hands in 1905. When he discovered that the farm needed draining he immediately set to work. Later in the same season—1906—he sought the assistance of the Office of Experiment Stations.

Plans and Construction.

The lines of tile on the upper bench, shown on the contour map of the field (fig. 7), were laid in the sand stratum with a view of affording an outlet of the least resistance and one that would keep the water the lowest. The lower bench lines were put in where the water cropped out. The depths and sizes of tile are shown on the map. After the lines were staked out and before deciding on the grades auger holes were put down every 200 feet and the depth below the grade stakes to the top of the sand determined. Then the grade was made so as to just cut through the clay subsoil into the sand stratum.

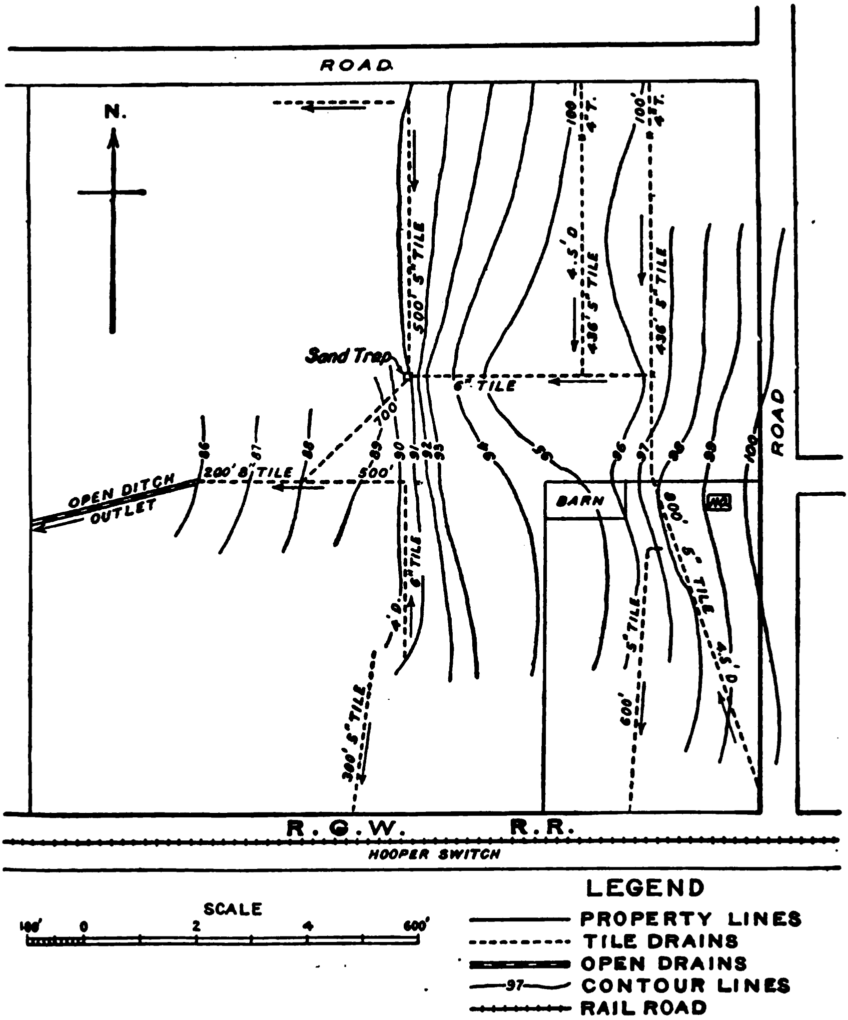


FIG. 7.—Plan of draining Hobson field, Roy, Utah.

Nearly all of the tile were laid on 1-inch by 6-inch boards to keep them in proper alignment.

A portion of the main line was plowed and scraped out, to a depth of 2½ feet, with a narrow slip scraper and one horse. A section of trench 500 feet long was left open during a cold snap, and before the tile were laid the banks broke off in great slabs from 6 inches to 1 foot in thickness, and up to 10 feet long. These had to be broken with pick and bar, as they thawed very slowly. The work was done at odd times by the owner and it was not practicable to get exact data of the cost of the labor.

Cost.

Tile:		
200 feet of 4-inch tile, at $34.20 per thousand feet	$6.84	
3,072 feet of 5-inch tile, at $46.30 per thousand feet	142.23	
1,200 feet of 6-inch tile, at $67.80 per thousand feet	81.36	
200 feet of 8-inch tile, at $113.80 per thousand feet	22.76	
3 wyes	1.75	
		$254.94
Lumber laid under tile:		
475 feet b. m. 1-inch by 6-inch by 14-foot lumber, at $30 per M	14.25	
1,333 feet b. m. 1-inch by 6-inch by 14-foot lumber, at $29 per M	38.65	
954 feet b. m. 1-inch by 6-inch by 14-foot lumber, at $28 per M	26.71	
		79.61
Labor cost, approximately 75 cents per rod		212.25
Total		546.80

Average cost per acre, $13.67.

Results.

That satisfactory drainage was obtained is evidenced by the fact that the ground would hold up loaded wagons any time during the spring, while before drainage, horses were mired while plowing as late as June. As a consequence of the draining, farming operations were possible earlier in the spring of 1907 than on neighboring farms which the owners thought needed no drainage. Though there were some spots where crops failed on account of alkali during the season, the improvement was easily noticeable. Very fine peas and potatoes were grown in 1908 on portions of the upper bench, which had been bare before drainage. The neighbors, who were skeptical before, now say that the work has already enhanced the value of this farm $1,000.

OGDEN EXPERIMENT.

The Wasatch Orchard Company undertook some drainage on their factory farm 1 mile southwest of Ogden, in 1907, under the direction of this Office. The soil is somewhat like that at Roy, with more hardpan, which is nearer the surface than at Roy. In the southeast corner this hardpan was only 3½ feet from the surface. The situation was probably typical of a number of similar areas in this district, and the results obtained here should be worth a great deal to farmers confronted with the same problem. Alkali and seepage water had been giving trouble for a year or two, and several acres were barren as a consequence. The accompanying map (fig. 8) is self-explanatory.

Plans and Construction.

In order to get the total available soil depth, the tile were laid into the hardpan about 6 inches. The digging in this formation showed that it was very porous and carried considerable water. The work was done during the summer, and much water was obtained, though the surface of the farm was dry. In the wettest portions the water was from 2½ to 3 feet below the surface.

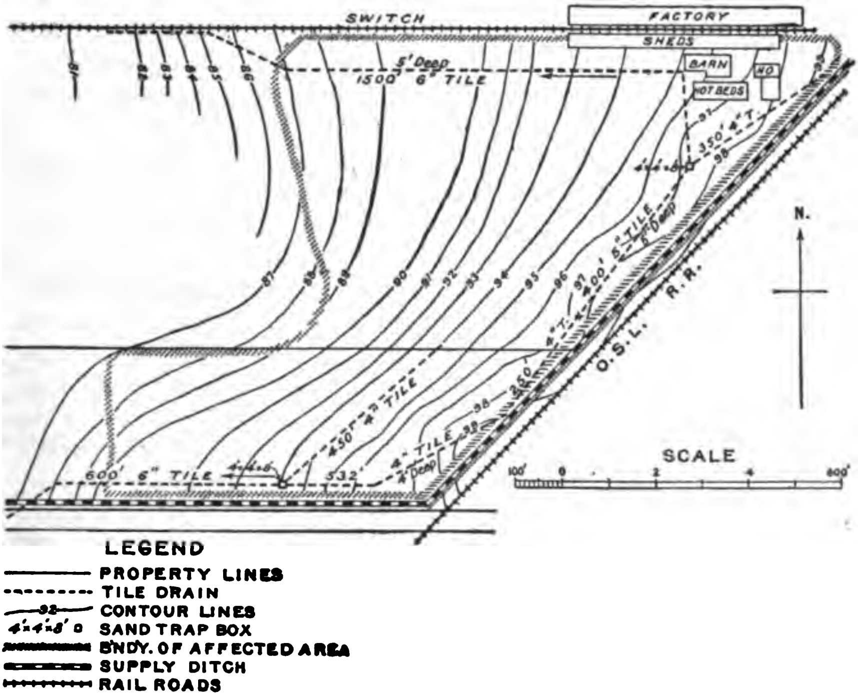


FIG. 8.—Plan of draining Wasatch Orchard Company's field, Ogden, Utah.

Cost.

The cost of this work was much more than it should have been. Labor was high and very scarce. City sewer-trench diggers were employed by the day; besides this, unnecessarily large quantities of gravel were placed around the tile.

Results.

The wet portions were well drained, and Superintendent Van Allen, who was somewhat doubtful at first, is now well pleased with the results. Good crops of peas and alfalfa were grown during the last two seasons on this land, which would not grow peas at all before drainage.

CLEARFIELD EXPERIMENT.

This work was done by the Clearfield Orchard Company on their orchard about 1 mile southwest of the Clearfield station, on the Oregon Short Line Railroad.

The soil is a fine sandy loam with a subsoil made up largely of fine sand, though on the Sand Ridge the soil formation is different from that at Roy and Ogden. Here it seems to have been formed or shifted about by winds, and small sand hills, knolls, and depressions are often found on the same farm.

The history and extent of the injury are practically the same as for the other places mentioned above. Several years before this work was begun an attempt was made to drain two small benches on the near-by Bishop White farm. On the upper bench a drain from 7 to 9 feet deep was laid, which was expected to intercept the seepage on both levels, but it failed to do so. A portion of this line was laid well up on the slope at the upper end to get more grade and failed to drain the narrow bench immediately below. Fine sand was encountered, but the tile were covered with gravel and sand boxes put in. This work was well done, but very expensive, and consequently discouraging. The Clearfield Orchard Company's orchard, immediately below, became affected in 1906, so that the leaves seemed to burn on a number of otherwise healthy trees. This was thought to be due to the effects of the alkali, which showed rather plainly on the ground. Several acres became so wet that spraying could not be done. The next spring the owners asked for advice, and the work described below was done, the Office making the plans.

The map (fig. 9) shows the location of the drain and other data. At the date of examination, the pond noted on the side contained 2 feet of water just above the division fence and stretched out to one-quarter of a mile long. The water was kept out of this farm by a dam, but the seepage, naturally, flowed through the soil to the orchard. This was not the only source of seepage, so the line was extended through the upper slope of the affected ground northwest of the pond. The minimum depth was placed at 4½ feet in the swale opposite the pond and the maximum 6½ feet in the ridge below the pond. The object of running the outlet line so far along the fence was to secure water for the wind-break trees.

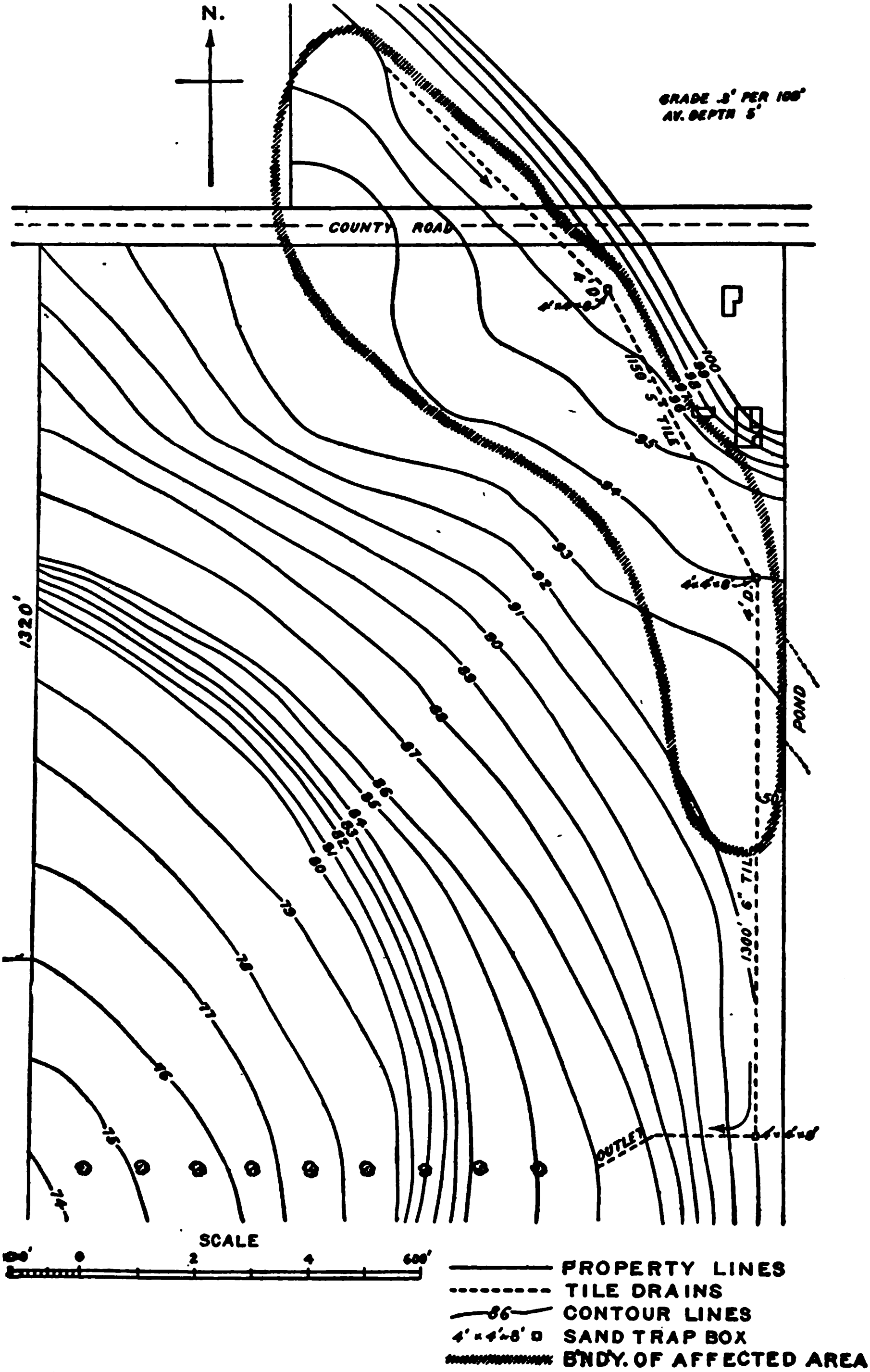


FIG. 9.—Plan of draining Clearfield Orchard Company's orchard, Clearfield, Utah.

Field Construction.

The digging was attended with difficulty on account of very fine sand and water and the inexperience of the laborers, which resulted in the tile being laid 6 inches above grade. When nearing the orchard, the trench was opened a few days before tile laying began, causing the land to become sufficiently dry to permit the distribution of tile by team over ground which was previously soft and miry.

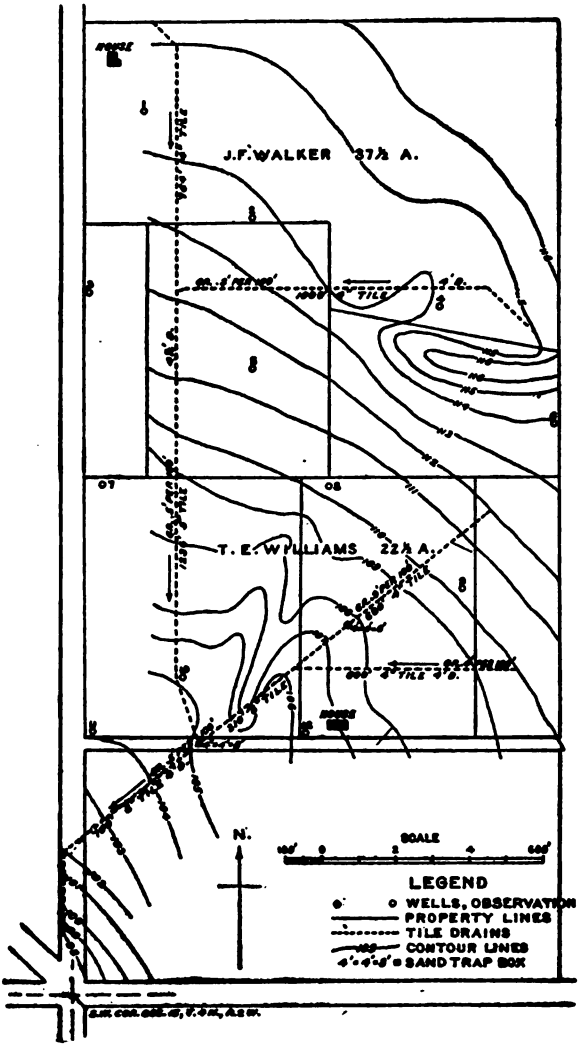


Fig. 10.—Plan of draining Walker and Williams fields, Syracuse, Utah.

Beneficial Results.

The wet ground has been very well drained, excepting a small area just west of the house and barn. From the results obtained it seems that the line of tile should have been laid about 100 feet farther down the slope. The company will lay an additional branch through this part during the coming season. The trees have apparently recovered, and the foliage and fruit were good last year. Plowing and other necessary operations are performed without trouble.

SYRACUSE EXPERIMENT.

This work was done on the adjoining farms of Messrs. J. F. Walker and T. E. Williams, some 3 miles down the slope from the Clearfield farm, under practically the same soil, subsoil, and water conditions. It was undertaken upon the recommendation of the Office, and completed according to the plans furnished. There was considerable water in the spring time and some alkali had made its appearance, both of which had seriously interfered with cropping. Water from artesian wells is stored in small reservoirs and used for irrigation. The seepage loss from these reservoirs was considerable and was thought by some to be the whole cause of the trouble. Later observations, however, pointed to two sources—this reservoir seepage and also the irrigation on higher lands. For plans, grades, and slopes, see figure 10.

Results.

The system is working well, but extensions into wet spots are needed on both farms. Extensions are already begun on the Walker farm, and both owners are well satisfied with what has been done. Other farmers in the same neighborhood are now taking up the work.

EMERY COUNTY INVESTIGATIONS.

Emery County is in the eastern part of the State, in what is known as the "Colorado Plateau." The soil is an alluvial sandy loam, underlain at various depths by shale. Mechanical analyses of the soils on the Huntington experimental tract show that the proportion of silt ranges from 28 to 55 per cent and that of very fine sand from 23 to 42 per cent. The upper layer of shale, whether on the surface or below, is a very tenacious clay. A foot below, the shale becomes looser and at several feet below is in large pieces, open enough to allow the free flow of water.

When these lands were first brought under cultivation they were remarkably fertile and, to all appearances, would never need draining. Within a few years spots of wet land began to appear in the fields, alkali accumulations followed, and the spots spread until whole farms had to be abandoned. Such conditions abounded throughout the valley. There was some talk of draining, but the close proximity of large gullies or arroyos to such lands, without any beneficial effect, made it seem impossible to drain, so the water-logging of farms continued and farms and portions of towns were abandoned until in 1904 it was estimated that 30 per cent of the land which had been under cultivation was at that time abandoned. As the trouble was increasing, it was only a question of a few years before whole tracts would have to be abandoned entirely.

HUNTINGTON EXPERIMENT.

It was with these prospects confronting the people that they applied to the State station for help. The work was begun in 1904, by making soil water observations at Huntington, and continued the following year by some construction. This Office and the State cooperated with the Bureau of Soils, Emery County, and Mr. E. L. Geary in making an experimental test on the farm of the latter.

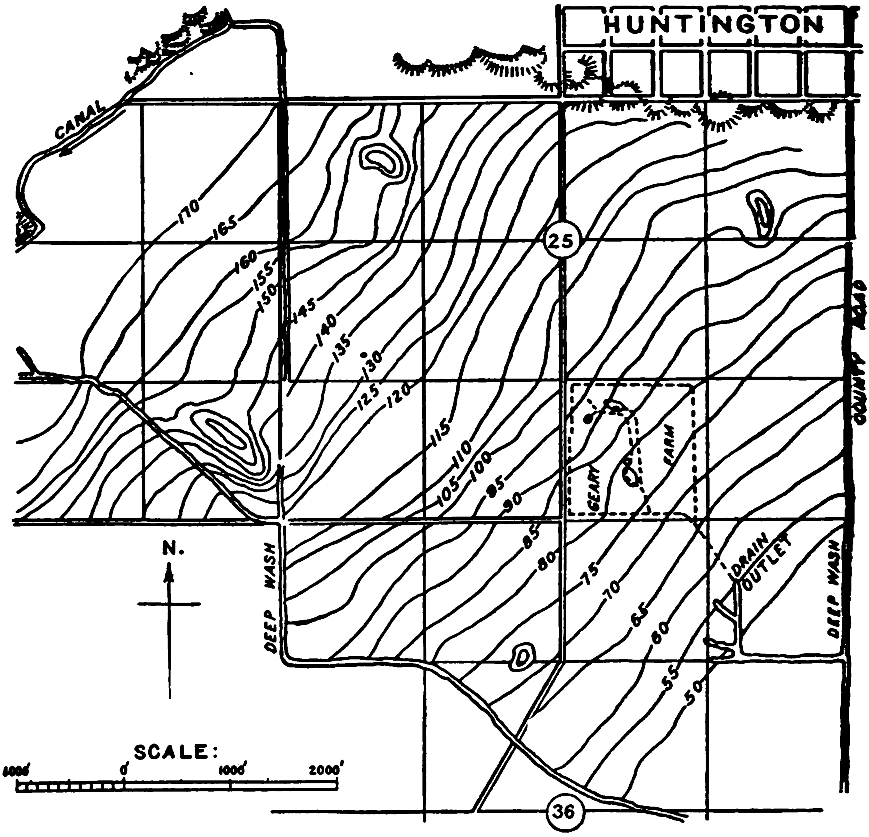


FIG. 11.—Field contour map showing location of Geary farm.

This tract was typical of the lands of the valley, and contained portions in all the varying stages of deterioration. The soil survey also showed that white alkali, ranging from less than 0.2 per cent up to 3 per cent, existed in the surface foot and to 6 feet deep. For the location of the Geary farm, with reference to the surrounding fields, see figure 11. Preliminary examinations of this farm were made, including a thorough subsoil survey by means of test pits, auger borings, and probings with a steel rod to a depth of 15 feet. The subsoil survey brought out the relation of the shale hardpan to the source of the water and alkali. This formation lay in ridges and knolls under an almost uniformly sloping surface. The two bogs shown on the farm map, figure 12, were directly over two of these shale knolls, and it was shown that these carried to the farm, from some distant source, water highly charged with alkali. Some lateral seepage came from neighboring farms, but the bulk of the water which kept these bogs miry for rods around and which kept the soil saturated, was undoubtedly from the first source. Water stood on the surface within a

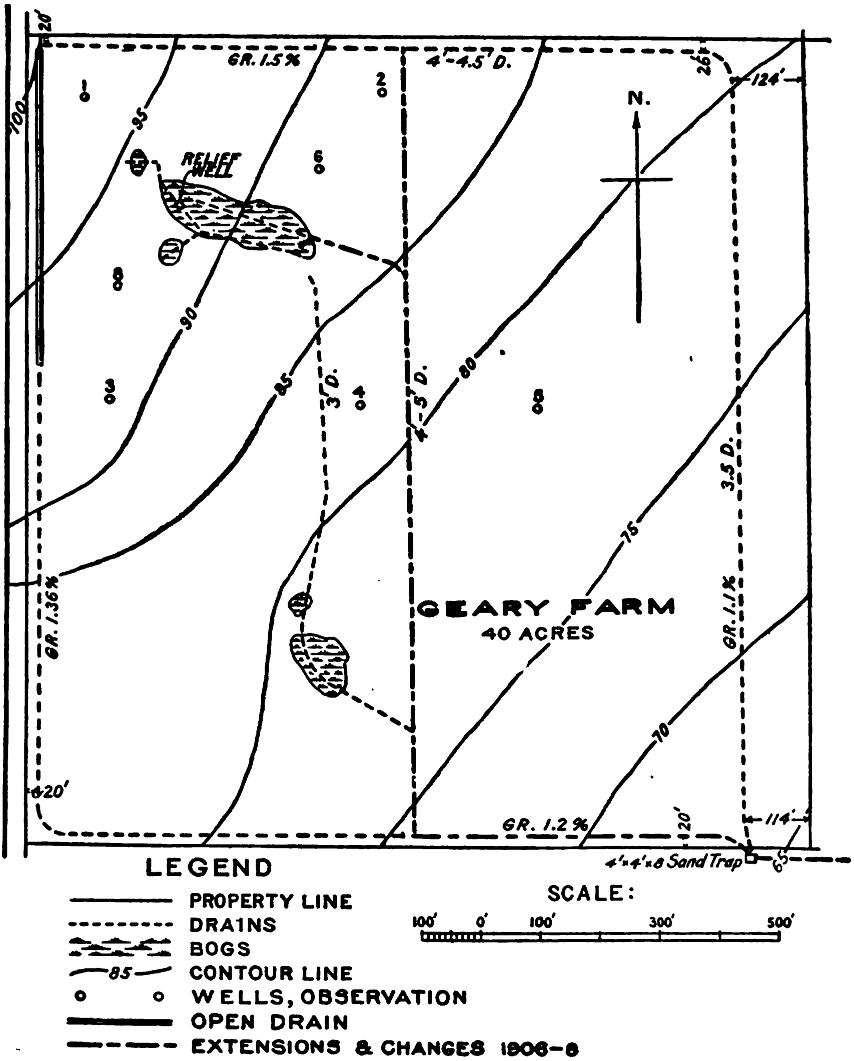


FIG. 12.—Plan of draining Geary farm, Huntington, Utah.

few feet of a deep gully or arroyo on the south of the farm. It was clearly evident from this and other indications that the intercepting method of drainage would be necessary.

Plans and Construction.

Draintile for covered drains was out of the question, on account of high freight rates and the distance from the railroad. Lumber was the next best material, and as this could be readily obtained it was chosen. Boxes were made of 2-inch by 12-inch plank for the outlet, and of 1-inch by 8-inch boards for the laterals, without bottoms in firm ground, and with bottoms for soft ground. (See fig. 13, *a* and *b*.)

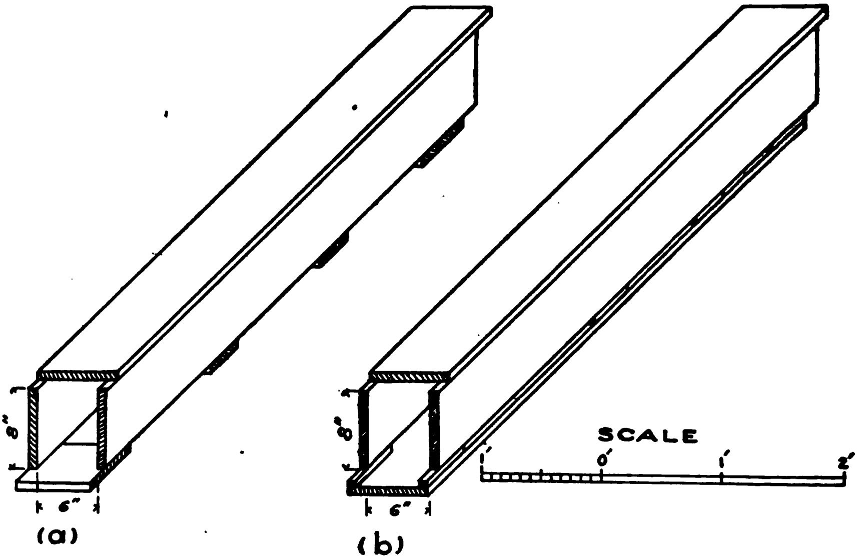
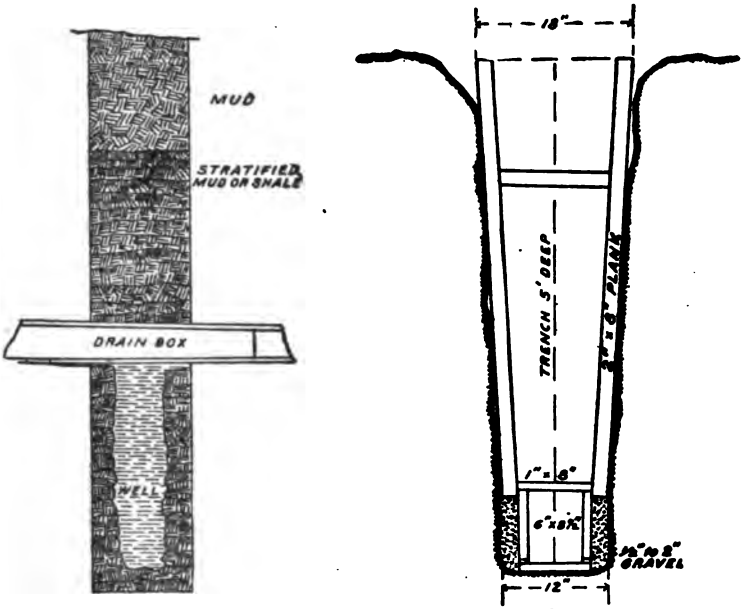


FIG. 13.—(*a*) Box drain for firm ground; (*b*) box drain for soft ground.

A line was cut into the bogs with the object of catching the water at a safe depth below the surface and conducting it away from the field. The upper drain of the central areas, shown on the farm map, was the first one constructed. The outside lines were laid as a protection against lateral seepage.

Some of the trenches were dug before the lumber arrived, and a heavy rain storm did considerable damage by causing the sides to cave in. About half of the digging was in such bad condition that it was impossible to get the boxes laid as deeply as planned, and in several cases the mud was pressed into the boxes continually. Flushing them with water was useless, but by cutting the boxes into short sections and keeping them laid and covered to within a few feet of the digging, some headway was made. The boxes were laid about

3 feet deep between the bogs, making it possible to get into the upper bog 6 feet deep. Here considerable water was encountered and from a well 4 feet deep (see fig. 14, *a*) in the bottom of the trench enough water rose and ran into the drain to give a head of 1⅝ inches over a 6-inch rectangular weir. This stream has been constant and the total discharge of the system has been nearly constant, except when affected by immediate irrigation. The discharge was measured at the outlet for a year, and gave an average head of 1 inch over a 12-inch rectangular weir and is still running. Most of this comes from the bog holes, and is highly charged with alkali. When nearing the bogs every contrivance failed, and water was turned in the trench to cut out the soft muck, which was run out over the field below.



(a) (b)

FIG. 14.—(*a*) Relief well on Geary farm, Huntington, Utah; (*b*) method of laying box drain, with gravel filling and plank sheathing, through soft ground.

Cost.

Where the ground was dry or firm and the depth not over 4½ feet, digging cost 40 cents per rod. Greater depths, up to 5½ feet, cost 55 cents per rod. The digging in shale was heavy work, and cost as much as $2 per rod for short sections. The average cost for the first central line, including shale and very soft mud, was approximately 90 cents per rod.

The cost of making boxes with open bottoms was about 10 cents per rod. Boxes were laid and blinded for 20 cents per rod, and filling cost approximately 8 cents per rod.

The total cost of $808.67 works out 11⅛ cents per linear foot and $20.21 per acre for the tract, though there is almost half as much more land drained outside of the field.

Extensions.

A portion of the west-side drain protecting the northwest corner became obstructed during the winter of 1905–6 and attempts to remove the obstruction proved unsuccessful. This section of the drain had been provided with boxes open on the bottom. Straw was thrown in the bottoms of the trenches before laying the boxes for the purpose of preventing the soft mud from squeezing into them. It seems that the weight of the soil caused it to flow into the boxes in spite of the precaution taken. As it was impracticable to remove these boxes, Mr. Geary decided to cut an open ditch, paralleling this section, between it and the fence. This ditch was washed to about 5 feet in depth; and plans were made for laying boxes in the same, providing bottoms for the boxes and filling in the sides with gravel. (See fig. 14, *b*.) The laying of boxes in this section has not been finished, owing to other troubles.

During the same season (1906) a change in the central line for conducting the water away from the bogs was planned and late in the same year was partly finished. The necessity of putting another line through here was due to the shallowness of the first central drain. When this first line was laid it was impossible to get the boxes to a greater depth between the bogs than 3 feet. This depth was not sufficient to prevent excessive evaporation along the line, but the drainage of the bog had dried out the land below, so that digging 5 feet deep was now possible. It was decided to put in this line, as shown on the map (fig. 12, p. 27), in about the center of the farm, with the object of providing a better outlet and diverting the water from the upper bog into this drain. This line was completed out to the bend immediately below the bog.

No further work on these extensions was done during the year 1906, and cropping operations were carried on during the summer of 1907. A greater part of the farm was planted to oats, and care was taken in irrigating to prevent any washing by surface water. Irrigation was carried on immediately over the drains on the south side. The surface water was kept out of the drains during irrigation, but the soil continued to run into the boxes for several days after the application of water, resulting in the complete obstruction of the drains. These obstructions caused the drainage water which was coming from the two bogs to rise to the surface and to seep away into the soil during the balance of the summer. There was no other outlet for this water, so repairs were undertaken in May, 1908.

Subsequently, all boxes were provided with bottom boards (leaving openings of one-fourth inch, as in fig. 13, p. 28) and packed with sand and gravel along the sides. As it was impracticable to dig a new line anywhere near these portions on account of the excess of water, an attempt was made to uncover the boxes on the south side of the farm by using surface water and washing the earth through the outlet ditch into the large arroyo below. This attempt resulted in obstructions forming in the outlet drain which made it necessary to uncover these boxes and remove them. After washing out the soft mud and providing an outlet for the drainage water, work on relaying the boxes was resumed. Boards 1 inch by 12 inches were nailed onto the bottoms of the outlet boxes, and they would have been relaid in the original outlet line had not the owners on the south proposed to cut an open ditch running east from the southeast corner of the Geary field to the county road. An outlet for the drainage of this system was offered, and 200 feet of boxes was laid along that line as a precaution against erosion of the ditch into the Geary farm. The balance of the closed boxes from the outlet line were laid on the south side. A new drain was constructed between the south side and the new central-line work laid in 1906. The necessity for this change was caused by an obstruction in the short diagonal section. After finishing the south-side repairs the completion of the central line was taken up. This line was extended through to the north side to protect the land below and to furnish an outlet through the reconstructed drain for water coming from the northwest side. The line extending northwest into the bog, with a branch for cutting the water of the upper drain over into the lower drain, was next taken up. All of the work done during the season of 1908 was under very difficult and discouraging conditions. The expense has been unusually high, and the complete reclamation of the tract is not yet attained. Three-fourths of the farm was planted to oats and a fair crop grown on possibly half of the farm. The barrenness of this field is slowly but surely giving way to improved conditions.

The total cost of making these extensions and repairs, including the work in 1906, was $557.45. This gives a cost per acre of $13.94, which, added to the original cost of $20.21, makes $34.15 per acre up to date.

In conclusion, it may be safely said that unless special precautions are taken in limiting the openings and protecting the same by gravel and sand, the use of covered drains in these soils will not prove very satisfactory. In addition to these precautions, irrigation must not be carried on directly over the drains, and where irrigation ditches must cross the drainage lines flumes should be provided. There is no question that this farm has been greatly improved, as evidenced by its appearance and the crops now growing. The obstructing of the drains and consequent rise of ground water on the south side of the farm also injured the Johnson tract on the south. The cost has been higher than land values would warrant in this particular case, but there is every reason for believing that success within the proper economical limits will be attained. Cultivation and irrigation will be carried on in the same way as it has been, and the Office will continue to watch the operation of the drains carefully until the experiment is completed.

SEVIER COUNTY INVESTIGATIONS.

The Sevier County work was done near Richfield, in the Upper Sevier River Valley, which extends from Gunnison on the north to Elsinore on the south. The valley is surrounded by high mountains, and although the rainfall is light (less than 9 inches) the supply of irrigation water is good.

The soil of the valley is a rich red clay, and was originally very productive. The seepage of surplus irrigation waters, however, soon began to destroy the lower lands, which, as is generally the case, were the most productive. Boggy places were formed and alkali made its appearance, until eventually large acreages were abandoned. The destruction has continued to spread, driving the farmers to higher lands, until it now becomes evident that unless the march of the alkali be checked total abandonment will be the ultimate result. The soils are generally charged with alkali, more than 37,000 acres containing from 0.2 per cent to 3 per cent. Richfield, although near the upper end of the valley, has its share of these troubles and is fairly typical. About 15,000 acres in its immediate locality are in need of drainage.

RICHFIELD EXPERIMENT.

This experiment was made on a tract of land between Richfield and Venice, just above the Vermilion Canal, by cooperation between the Office and the owners, William and Junius Ogden and William Gardner.

The tract has a general slope of about 0.5 per cent toward the southeast. The very highest portion only was producing crops, the balance being covered with salt grass. Some spots were entirely bare and flooding did not seem to effect much improvement. The source of water was lateral seepage from higher lands, flowing through a sand substratum.

Plans and Construction.

Two parallel lines of tile 600 feet apart were planned, one along the upper slope to intercept the water and the other below, each to have short branches to tap particular spots and both having a common outlet, tiled under the canal and then open to the river. The average depth was 5 feet, the grades being from 0.3 to 0.5 per cent, in order to carry away the fine sand, etc. Plans are shown on the map (fig. 15). The open-trench outlet was proposed to reduce first cost, but was later replaced with a 10-inch pipe drain.

The open trench was first dug, and then the work of placing the tile under the canal was undertaken. A stream 15 feet wide by 1 foot deep was flowing in the canal and could not be shut off, so it was necessary to do the trenching and tile laying in sections surrounded by an improvised cofferdam, built of sand bags, extending partly across the canal. Sewer pipe was used, and the joints cemented to prevent leakage from the canal.

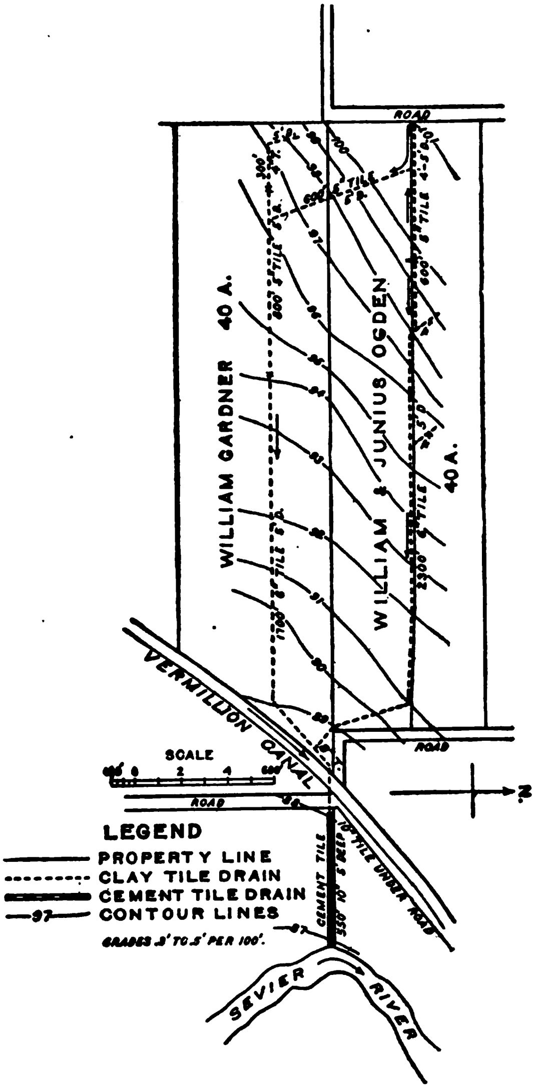


FIG. 15.—Plan of draining Gardner and Ogden fields, Richfield, Utah.

The digging was done by inexperienced laborers, and some little trouble resulted. In one case 400 feet of trench had been excavated and was left open from Saturday until Monday morning, with the result that seepage caused the sides to cave in and made the waste material so sloppy that an attempt to remove it was unsuccessful and an offset line had to be constructed. Another difficulty was the settling of fine soil particles in the tile, requiring them to be flushed out, which made work in the trench very disagreeable. In most of the work the back filling had to be kept up within a few feet of the excavating.

The best results were obtained by using a team of three diggers, each taking out a spading, the first keeping less than 2 rods in advance of the finished trench and the last grading the bottom as he removed the final spading. A tile layer accompanied the diggers and kept the tile laid and blinded to within a few feet of the diggers.

Cost.

Tile was shipped from Salt Lake at a freight cost of 24 cents per hundredweight. Labor was expensive and hard to get, so the final cost was rather high. Day labor cost $2 for eight hours.

Tile f. o. b. Richfield:		
1,000 feet 4-inch tile, at $47.50 per 1,000 feet	$47.50	
2,000 feet 5-inch tile, at $71.25 per 1,000 feet	142.50	
4,000 feet 6-inch tile, at $92.50 per 1,000 feet	370.00	
150 feet 8-inch and 10-inch sewer pipe, seconds	27.42	
50 feet 10-inch sewer pipe, at 49 cents per foot	24.50	
6 feet 6-inch tees and 1 8-inch wye	2.20	
10 barrels cement for 600 feet 10-inch tile	50.00	
Total		$664.12
Hauling, digging, laying, etc.:		
Hauling 50 tons, 2 miles, at 25 cents per ton mile	25.00	
450 rods trenching, at 60 cents per rod	270.00	
450 rods tile laying and filling, at 25 cents per rod	112.50	
25 days' labor, making cement tile, at $2 per day	50.00	
Total		457.50
Total cost		1,121.62

As the field contains 80 acres, the unit cost is $14.02 per acre.

Results.

The work was completed in the spring of 1907. A great deal of water was discharged, apparently from every part of the system. Damp spots were dried and the spread of alkali stopped. Irrigation water was readily removed and the land was ready for cultivating early in the spring. Fair crops were raised the first season on portions that had been poor for several years. Ten acres of the Ogden farm, planted to oats in 1908, gave an average yield of 50 bushels, which is pretty good for that locality. Mr. Gardner has subjected his ground to a thorough leaching process and will cultivate a part of it this season (1909) with confidence of general success. Water is still being discharged, and conditions are so gratifying that other projects are under way in this locality. A drainage district comprising 1,000 acres has been formed at Venice, where the farmers have great faith in the value of drainage.

WASHINGTON COUNTY EXPERIMENT.

This experiment is being made in the Washington field, near St. George, in the extreme southwestern part of the State. St. George was settled in the early history of Utah, and irrigation has been carried on for many years. The high-line canal, which waters all the land on the south side of the river and heads some distance up the Rio Virgin, was constructed in 1891–92. The land, with water rights, cost $67.50 per acre, and when in good condition gives an annual return of $20 to $22 per acre for ordinary crops, and more for fruit or vegetable crops, which of course require more attention.

Subsequent to the opening of this field came a cycle of dry seasons. The land was irrigated copiously, and all portions bore abundantly. As the dry cycle kept up winter irrigation was resorted to, with a view of storing water in the soil. Heavy flooding was also carried on to prevent the usual settling of portions of the tract after planting. Another source of surplus water was that stored in ponds and used for stock-watering purposes. The natural result of all this was the accumulation of water in the low spots, the general saturation of the ground, and ultimately the appearance of alkali. The alkali spread rapidly until it covered more than 50 per cent of the cultivated area and caused its abandonment. The special reports cover the Washington field only, but the conditions in this field are typical of those in others.

A soil survey was made in 1905 by A. T. Strahorn, of the Bureau of Soils. The soil was classified into four types, Nos. 1, 2, 3, and 4.

Soil No. 1 is found in the extreme northwestern part of the field, well up toward the canal, and covers but a small area. It is a yellowish red sand, medium to coarse, containing small rounded gravel at various depths, and extends to a depth of 3 feet. Along the lower edge a fine silt has been deposited by irrigation waters. The soil is loose and on an elevation; so the drainage is good, and little alkali has made its appearance. After an application of water the surface bakes slightly, but crumbles easily. The soil was weathered from the hills on the west, the lighter portions being carried farther away. Alfalfa occupies the tract and yields from 4 to 5 tons per year in four crops.

Soil No. 2 covers most of the slope of the field, and is a red, sandy loam of uniform texture, having a depth of 3 feet or more. The only variations are a layer of gypsum and sand hardpan in the southern part of the field, and a thin stratum of coarse sand. The nature of this soil is such that it is easily cultivated, bakes slightly upon being wetted, but offers no particular resistance to the growth of plants. It is not much affected by alkali and yields good crops of alfalfa, often 6 tons per season. Berries and fruits can also be grown to good advantage.

Soil No. 3 covers the floor of the lowland and consists of from 0 to 12 inches of loam or clay loam, brown or red, underlain by a red loam to 36 inches. The loam of the last foot is often replaced by a heavy sand loam. This soil comprises the " old lake bottom " and is heavy and sticky and difficult to handle, as it turns up in large clods, hard to pulverize, if plowed too wet. If plowed too dry, it powders and then puddles upon being irrigated. This puddled surface proves a barrier to the growth of grain. The soil was deposited from slow-moving or standing water, after the coarser grains had been left on the slopes. It is now so highly impregnated with alkali as to be unfit for cultivation, and is also a basin for all surplus water. A heavy growth of sedges and tules, with a border of salt grass, occupies the wettest parts. Useful vegetation has almost entirely disappeared.

Soil No. 4 covers a narrow strip on the west slope next the slough and consists of 36 inches or more of a clay loam, brown with organic matter in the surface, and represents the finest and latest deposit of the water-borne particles. Alkali is strongly evident, but the water table is lower than in that of soil No. 3.

There are large quantities of sulphates, considerable quantities of chlorids, and small quantities of bicarbonates in all of the classes of soil described. The alkali is quite uniformly distributed throughout the first 3 feet, being slightly stronger in the surface.

EXPERIMENTAL TRACT.

The location of the tract is shown on the field map (fig. 16), and local conditions on the experimental tract map (fig. 17). The soil is mostly No. 2, except in the southwest corner, where soil No. 3 is in evidence. This entire tract has been under cultivation, and all of it yielded abundantly except the north 20 acres, which seemed lacking in fertility. The tract owned by Mr. McArthur soon showed the effect of the irrigation of the higher lands. The wet area increased, and alkali appeared in sufficient quantities to prevent the growth of crops. The other tracts were partly affected in the same way. The Brown and Woodbury fields produced alfalfa only in the higher portions.

Plans and Construction.

These fields were examined in 1904, and the 1905 work was begun under a cooperative agreement, the owners to furnish the labor, while the Office supplied the materials and superintendence. The system consisted of four parallel lines running diagonally across the slope, equidistant from each other and intended to act as intercepting drains. The upper one, placed at the upper edge of the saturated area, was the only one crossing the entire tract. The object of this was to determine how far the effect would reach down the slope.

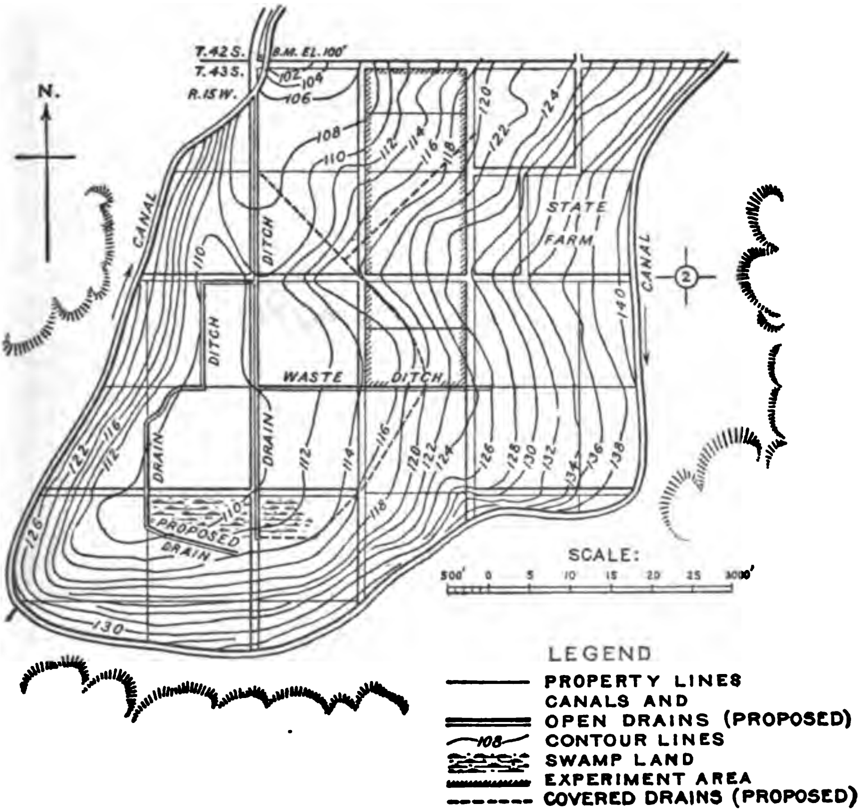


FIG. 16.—Map showing proposed drainage of Washington field and also location of experimental tract, St. George, Utah.

Lumber box drains were used, as the use of tile was prohibited by excessive cost. The lines were kept well away from trees to avoid the obstruction of the drains by roots. The depths were from 3 to 6 feet, and the grades from 0.1 per cent to 0.9 per cent. The tools used were long-handled shovels for digging and tile hoes for grading. The diggers worked in teams of two. Sections of the box drain were laid as the digging progressed. The drain was completed at a rate of 200 feet per day, at a cost of 95 cents per rod.

Cost.

The work of making boxes, digging, and laying was done together, so that separate costs could not be kept. The cost of making boxes would be about 70 cents per 100 feet. The following table shows the cost as done by different men. The Brown work was the heaviest. Mr. Moss used a team for a part of his work.

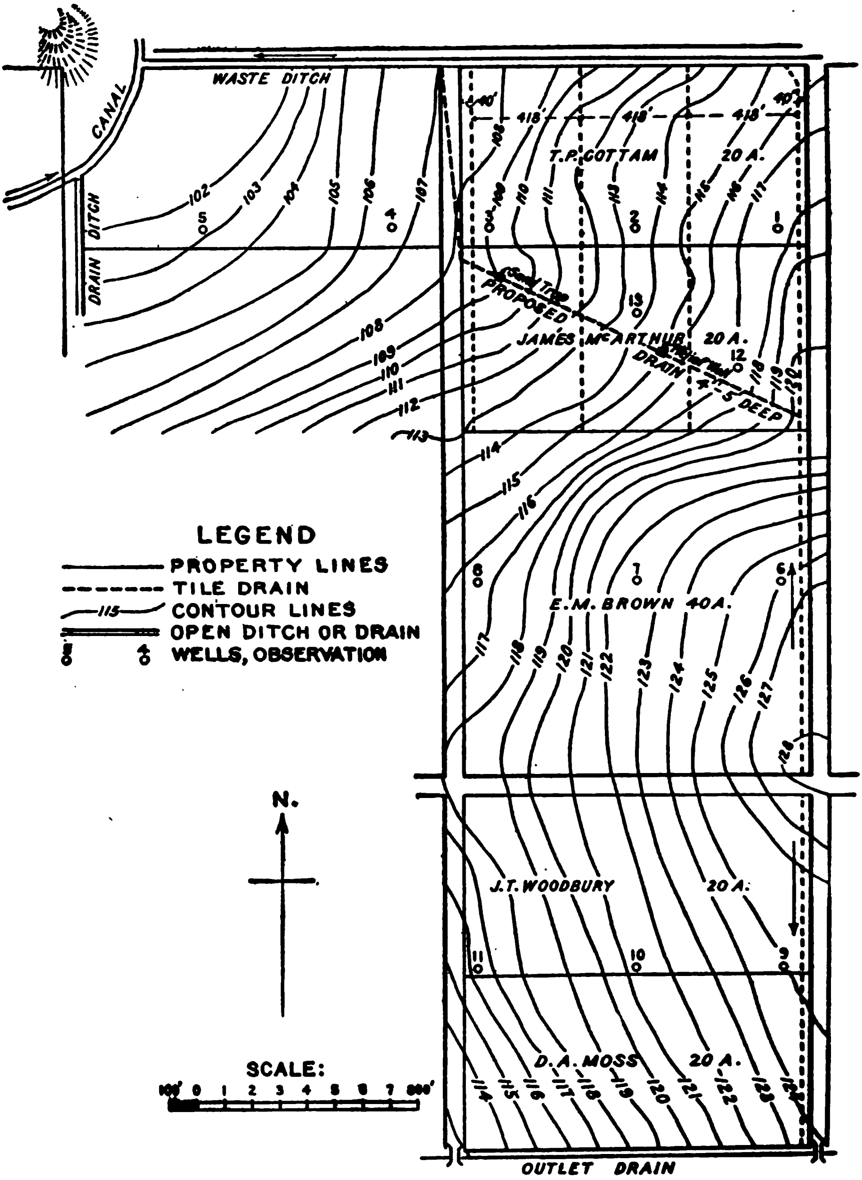


FIG. 17.—Plan of draining experimental tract, St. George, Utah.

Cost of draining experimental tract, St. George, Utah.

Owner.	Acres.	Length of drain.	Cost per 100 feet.			Amount.	Total.
			Digging, making, and laying.	Filling.	Total per 100 feet.		
Cost of labor.							
T. T. Cottam	20	2,672	$3.73	$0.60	$4.33	$115.70	
James McArthur	20	2,672	4.14	.40	4.54	121.30	
E. M. Brown	40	1,249	4.40	.72	5.12	64.00	
J. T. Woodbury	20	660	4.39	.83	5.22	34.50	
D. A. Moss	20	640	5.78	1.09	6.87	44.00	
Total		7,893				379.50	
Surveying						22.00	
							$401.50
Cost of material.							
14,633 feet b. m. rough lumber, at $31.50 per M						460.94	
396 pounds 10-penny nails, at $0.057 per pound						22.57	
							483.51
Grand total							885.01
Actual cost per 100 feet for labor						4.81	
Actual cost per 100 feet for materials and surveying						6.40	
Total						11.21	

Costs per acre range from $3.60, where one line was used, to $14.61, where four lines of drains were necessary.

Results.

The results of this system have not been very gratifying, although the ground-water level was lowered considerably, and, under the ordinary methods of cultivation and management, the crops showed an improved condition. Irrigation water found its way into the drains and carried a great deal of ground with it, with the result that the entire system has become inactive.

Extensions.

Some new work, using boxes with narrow openings and gravel-filter packed around the boxes, as at Huntington, was begun in 1908. This drain was installed on the farm of Mr. McArthur and consisted of a covered box drain running diagonally across the field from the southeast to the northwest at a uniform depth of 5 feet. A well, intended to relieve substratum pressure, was sunk near the center of the field and in line with the drain. This well was 10 feet deep and 4½ feet square and boxed up. Water rose in the well and flowed out of the drain, but as this movement was discontinued as soon as the ground-water level fell below the level of the drain, it is not thought to have been due to substratum pressure. The drain has a grade of 0.2 per cent for the first 100 feet to a sand trap, 0.8 per cent for the next 500 feet, and 1 per cent for the remainder of the length.

It consists of boxes 6 inches by 6 inches, having the bottom separated from the sides by means of short lengths of lath. The drain empties into a tight box conduit, 650 feet long, running north to the open ditch, along the county road, into which it discharges. This conduit is the property of the Washington Field Irrigation Company.

The trench was dug by hand, and back filled by means of a plow and two teams.

Cost.

Well and sand trap:		
Digging well and casing same, 3 men 3 days, at $2 per day	$18.00	
Making casing, 1 man 2 days, at $2 per day	4.00	
Lumber for casing	3.00	
Nails	1.00	
Rope for windlass	1.75	
Total cost of well		$27.75
Labor, making sand trap, 4 men 1 day, at $2 per day	8.00	
Lumber	2.00	
Nails	.75	
Total cost of trap		10.75
Total cost of well and trap		38.50
Digging 86 rods of trench, making and laying boxes, and back filling:		
Labor		163.40
Nails	$7.20	
Gravel	27.52	
Lumber	100.05	
Cost of material		134.77
Total cost of trench		298.17

To get an idea of the cost of draining land in this locality, data were taken from the previous experiment. Material is necessarily expensive by reason of the geographical position of St. George. The work was done in summer and also when the water was high, two important factors in increasing the cost of labor.

The total cost was shown to be $298.17, which gives a unit cost of $3.47 per rod and $14.90 per acre. This cost will be increased slightly if it is found necessary to add a lateral to the system.

Results.—This drain was finished early in July, 1908, and discharged some water for a short period, but the water level soon fell below that of the drain, where it remained until November. During the winter a stream of about 0.05 cubic foot per second was discharged, more than half of which came from above the relief well. No prediction as to the ultimate success of this drain can be made at this time.

Proposed Extensions.

Some special examinations were made in this locality in the fall of 1908 to determine the source of the seepage which is destroying the lower Washington field. The theory had been advanced that the water was under pressure in the lower parts of the field, being confined by a hardpan, through which it found its way in weak places or breaks. If such conditions were found, relief wells were to be installed in the hope of providing an outlet for the water.

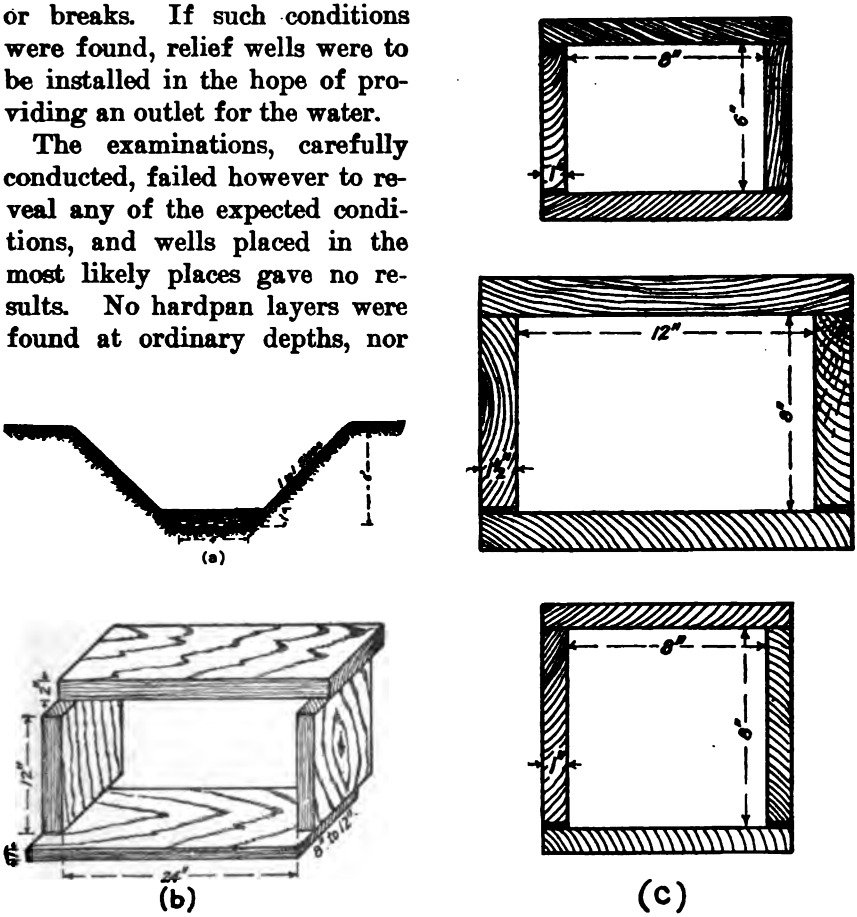


Fig. 18.—Proposed trench and drains for Washington field, St. George, Utah: (*a*) Cross-section of open trench for main drain; (*b*) detail of box drain for covered main drain; (*c*) cross-sections of box drains for branches I, II, and III.

The examinations, carefully conducted, failed however to reveal any of the expected conditions, and wells placed in the most likely places gave no results. No hardpan layers were found at ordinary depths, nor was any water under pressure discovered. The ground water was fairly level throughout the slough and continued level until it pinched out on the slope, on the west and south sides, and the southeast corner. On the east side, throughout the length of the experimental tract, however, the water followed the slope of the surface up to within one-quarter mile of the canal, whence it again became nearly level. It was also found that the ground under the canal was as dry as dust to a depth of 15 feet. These facts seem to indicate that the water comes directly from irrigation of the higher lands in the field. The investigations, in connection with past experience and data gathered at various other times, point out the necessity of constructing deep, open ditches of ample capacity, tapping the lowest portions of the field and discharging toward the river. As an important supplement, carefully placed intercepting drains should also be used on the gentle slope to the east. The branch drains should be covered and the main also, where it cuts through boggy places; or, as the main would lie along a public highway, it might be advisable to have the whole length covered. A proposed system is shown on the map (fig. 16, p. 37). Sections of the proposed trench and conduits are shown in figure 18, *a*, *b*, and *c*.

Estimated cost.

Excavating main drain, 12,845 cubic yards, at 15 cents per yard	$1,926.75
Excavating trenches for branches, 14,250 feet, at 7 cents per foot	997.50
Lumber for small boxes, 25,000 feet b. m., at $30 per 1,000 feet	750.00
Lath, 36 bundles, at 25 cents per bundle	9.00
Nails, 505 pounds 10-penny and lath nails, at 6 cents per pound	30.30
Lumber for branch II, 30,187 feet b. m., at $30 per 1,000 feet	905.61
Gravel for filling around boxes, 14,250 feet, at 2 cents per foot	285.00
Labor in making and laying boxes, 14,250 feet, at 1 cent per foot	142.50
Back filling, 14,250 feet, at 1 cent per foot	142.50
Total	5,189.16

If it is found advisable to use a covered main, the following will be the cost of same:

Excavating trench, 5,780 feet, at 14 cents per foot	$809.20
Lumber, part A, 17,600 feet b. m., at $30 per 1,000 feet	528.00
Lumber, part B, 15,840 feet b. m., at $30 per 1,000 feet	475.20
Lumber, parts C and D, 35,586 feet b. m., at $30 per 1,000 feet	1,067.58
Labor, making and laying, 5,780 feet, at 3 cents per foot	173.40
Nails, 1,126 pounds 10-penny and lath nails, at 6 cents per pound	67.56
Back filling, 5,780 feet, at 2 cents per foot	115.60
Total for covered main	3,236.54
Cost of branches	3,262.43
Total, using covered main	6,498.97
Total, using open main	5,189.16
Difference	1,309.81

Cost per acre, using open main, $6.83; using covered main, $8.55.

This proposed system, as elaborated by experience in the field, is a development of the original plans.[a]

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 158, part 9.

DRAINS IN THE TOWN OF ST. GEORGE.

During the fall of 1905 the town council put in a lumber box drain, following the plan of the field work, under direction of the drainage

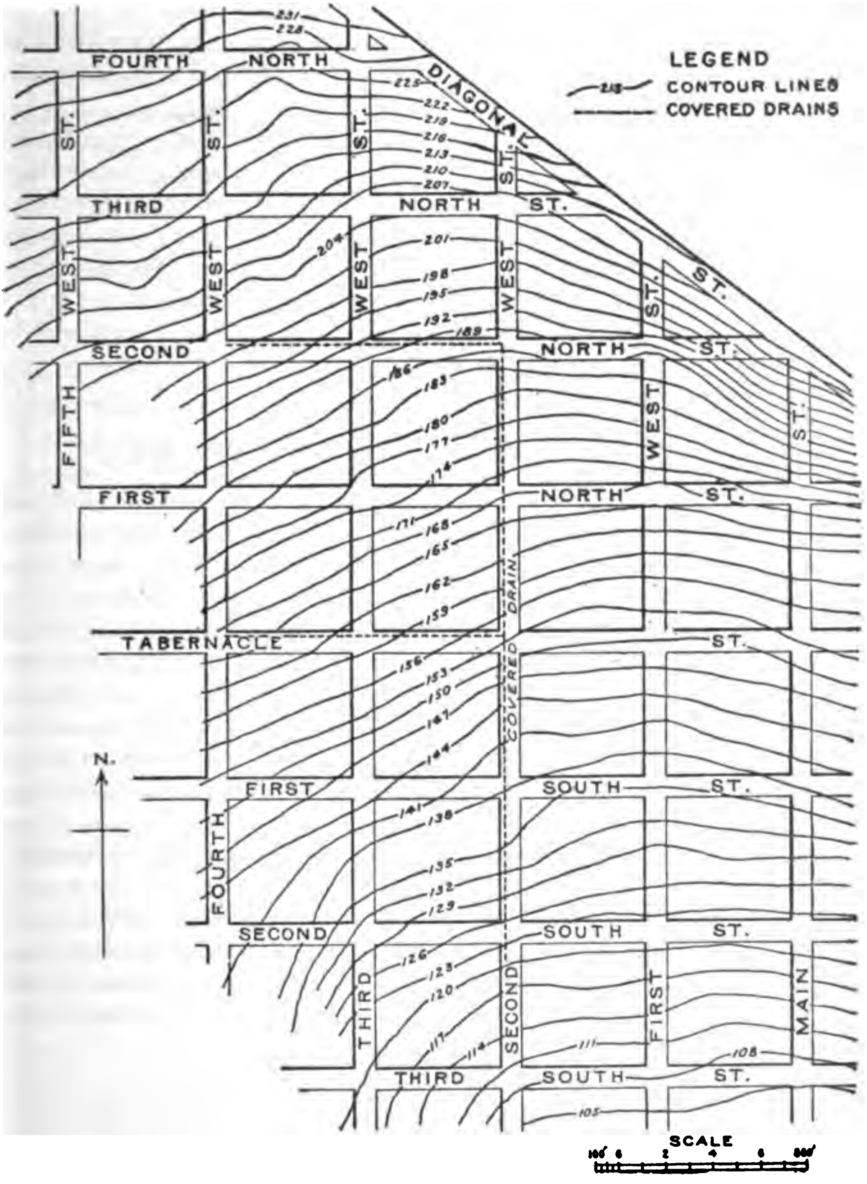

FIG. 19.—Town drainage map, St. George, Utah.

engineers of this Office. The main was laid up Second West street, as shown on the accompanying map (fig. 19), and two laterals west on

Tabernacle and Second North street to Fourth West street. This portion of the town had been wet for several years and was typical of the field condition. The drains were made of 1-inch by 6-inch boards, without bottoms, and were laid on an average of 5 feet deep. Grades ranged from 1 per cent to 2¾ per cent. Some construction troubles were encountered. Quicksand and loose ground gave some trouble, and several ridges of cemented sand, running east and west, made the use of a pick necessary.

This system has proved very successful, and extensions are planned. Wet places were dried and vegetation greatly helped. Some care here has also been found necessary to prevent irrigation water from finding its way into the drains. Such trees as the tamarack can not be permitted in the vicinity of the drains. During the last year trouble has been occasioned by the water cutting outside of the boxes and letting the surface ground fall in, thus leaving objectionable holes. Hereafter the city will use drain boxes with bottoms and with gravel packed along the sides.

DRAINAGE OF IRRIGATED LANDS IN OTHER STATES.

Passing to other States, it should be noted that irrigated land has been successfully drained by some one of the methods employed in Utah. Some of the wet lands about North Yakima, Wash., have been reclaimed by underdrains placed diagonally across the slope at a depth of 5 feet, in such a manner as to intercept the underflow from the higher lands, which are so largely underlain by gravel as to permit a ready flow of soil water to lower lands. These drains are discharged into receiving drains, either open or covered, which lead the water to some natural stream. Where the construction of the intercepting ditches has been omitted the land has not been satisfactorily drained.

The well system has proved valuable and often efficient in sections of Colorado, where the gravel which supplies the water lies 8 or 9 feet below the surface, and also in some instances where the loose loam soil rests upon a stratum of hard clay. Wells of any convenient cross section are excavated to the water-bearing stratum, from which a tile or box conduit, laid about 4 feet deep, leads the water which rises in the well into a receiving drain.

Where the land is level and the soil fine and homogeneous in character, like that near Fresno, Cal., it has been found best to lay underdrains about 6 feet deep directly through such lands as are affected by seepage and alkali. These collect soil water from a considerable distance on either side by ordinary percolation and deliver it into a sump, from which it is pumped into surface ditches. The difficulties which attended the construction of the drains in the Fresno district were similar to those described elsewhere in this bulletin. It has been found necessary to observe the same precautions in the subsequent management of both drains and fields as is found necessary in Utah.

PRINCIPLES AND PRACTICE.

LANDS NEEDING DRAINAGE.

Irrigated lands needing drainage may be divided into three classes:

(1) Those injured by excess of water only.

(2) Those affected by an excess of both water and alkali.

(3) Those having an excess of alkali only.

The first class is the least extensive of the three, the extent of injury depending upon the value of the crops that may be grown on the land when dry. The greatest danger of serious loss in this kind of land is that alkali may accumulate in injurious quantities with the lapse of time. In the irrigated region there is very little seepage water which does not contain some alkali in solution, which tends to accumulate to an injurious degree in saturated land. Inquiry into the history of lands which have become badly affected with both alkali and water show that when injury first became noticeable such lands could have been protected from further injury with as much profit as attended the reclamation of lands affected by water only.

It is to the second class that most of the lands belong which now need drainage in the irrigated sections. Alkali accumulations usually follow accumulations of seepage water. If one admits that this condition is a forerunner of total abandonment, surely no argument is necessary to convince him that such lands belong to the class that should be drained.

Lands of the third class are principally those in the virgin state, having enough alkali uniformly distributed through the soil to a depth of 6 feet to cause crop failure after a few years of irrigation, because of insufficient underdrainage. The lowlands of Millard and some of those in Salt Lake, Weber, Boxelder, and Emery counties, Utah, belong in this class. If irrigated lightly, the alkali will in time become concentrated at the surface, and if irrigated copiously, without underdrainage, water-logging will follow.

ALKALI AND GROUND WATER.

The relation of alkali to drainage is important and must be taken into account. In speaking of alkalies in his book on "Soils," Hilgard says:

> They are the natural result of a light rainfall, insufficient to leach out of the land the salts that always form in it by progressive weathering of the rock powder, of which all soils largely consist.

Ordinarily alkali is made up of one or more of the following salts in varying proportions: Sodium chlorid (common salt), sodium sulphate (Glauber's salt), magnesium sulphate (Epsom's salt), calcium chlorid, and calcium sulphate, all of which are white alkalis, and sodium carbonate (sal-soda) or black alkali. The latter is so called on account of the dark stains on the ground caused by the dissolution of the soil humus or vegetable matter. These salts and also the mineral plant foods are readily soluble in water, so that in the humid countries the constant leaching removes not only the injurious salts but also part of the plant foods. This accounts for the intrinsic fertility of the arid lands as compared with humid lands. The account of the origin of alkali naturally suggests the control by irrigation and underdrainage.

Of the fundamental principles, those relating to ground water and its movements are perhaps the most important. There is no question that seepage is an actual accompaniment of all irrigation. It has been found in all irrigated countries, doing damage and requiring drainage. The sources of supply are leakage from canals, surface applications, and precipitation. If the soil has the capacity for discharging this water as fast as it is supplied no damage will be done. If, on the other hand, more than its capacity is supplied trouble will surely follow. Soils in the Bear River Valley, Utah, having a depth of 40 feet and a fair surface slope have been known to fill after fifteen years of irrigation until water rose to the surface, doing considerable damage.

A proper appreciation of seepage conditions often involves a knowledge of the ability of water to transmit pressure between two points, due to differences of elevation. This is often manifested in irrigated sections by ground water springing up through the innumerable soil pores. Such a condition indicates a porous substratum filled with water exerting a pressure. When this substratum is too deep to cut into by a drain, outlet wells connecting with the drains at an ordinary depth afford the best solution.

Another physical property affecting the movement of ground water and of great importance is that called capillary attraction. This phenomenon was named from the inherent ability of liquids to rise in small hair-like or capillary tubes above their free surfaces. Water rises higher in the tubes and also in soil particles than any of the other liquids. This property is most essential to plant life and crop production, but uncontrolled in alkaline soils it hastens the accumulations of alkali at the surface. In soils varying from coarse sand to very fine clay, water will rise by this attraction from 2 to 6 feet. When the surface is allowed to become hard and baked, as when abandoned or allowed to stand idle, a surface tension is formed which increases this attraction and the consequent evaporation. It is the evaporation of large quantities of water containing alkaline salts in solution that does the damage. The evaporated water passes off nearly free, leaving the alkali in the surface soil. Experiments have shown that of the water applied in ordinary irrigation, without cultivation, from 30 to 50 per cent is evaporated from the surface. If, in addition to this, seepage water from higher lands or canals containing much alkali is within reach of capillary attraction, and the surface poorly cared for, thus increasing evaporation, alkali accumulations surely follow. A minimum depth of 4 feet for drains, with cultivated or shade crops, has been the practice of the drainage engineers of this Office, though deep drainage from 5 to 6 feet is preferred.

PLANS FOR DRAINAGE.

The soils of the arid regions have not been subject to percolating water since their formation, as the humid soils have been, and consequently are without the drainage pores of the latter. If they have any water pores at all, they are those of the water doing the damage. The water applied to the higher lands affects the lower lands, where it flows out or comes near the surface, whether in light or heavy soil. In moving laterally through the body of the soil the water will flow along the lines of greatest slope and will not drain well into tile lines parallel to its movement. The drainage water in all of these experiments has found its way through some special underground passage, or stratum, or some modification of these, rather than uniformly through the soil. The experiments in Emery and Weber counties were particular examples of the flow through some special underground passages, while the others were modifications. Conditions similar to those in Emery and Weber counties were observed in Paonia and Delta, Colo. At both of these places the efforts to drain the land were proving unsuccessful. These and a dozen other illustrative examples may be cited where special treatment was necessary; but those named are enough to show that the method of intercepting the water as it enters the field or soil, either by lateral seepage or some lower passage, is highly essential to success. However, intercepting drains are not all that are necessary. In nearly every instance outlet lines through the lowest wet portions are absolutely necessary, as is the case in humid sections.

Before drainage work can be taken up with any surety of success these underground conditions must be determined. If expensive mistakes are to be avoided, the subsoil examinations must not be neglected. The first method of making such examinations is that of digging test pits. Under ordinary conditions a depth of 6 feet can be reached without any difficulty. The test pit is also valuable for showing the nature of the digging for which special methods may be necessary. Another method is to use a soil auger, made of a 2-inch wood bit and ½-inch gas pipe, with which holes can be put down 12 feet, if gravel is not present. A long steel rod probe ⅝ inch in diameter can often be used to advantage in soft ground.

The kind of drain to be employed in farm drainage will be determined largely by local conditions. Open ditches are sometimes used for farm drainage, but more often for outlet and main drains. The principal objections to the use of open ditches for farm ditches are the loss of land and the high initial cost if sufficient side slope is given them. If side slopes are left steep the maintenance expenses are high.

Covered drains may be divided into the following forms: Tile, lumber boxes, stone, brush, and mole-plow drains. Burned clay tiles, chiefly in a round form and in 1-foot sections, have been in use for more than four hundred years and have proved satisfactory. They have been known to endure for one hundred years. Some kinds of clay tile, when left upon the surface of the ground, will be disintegrated by soil alkali and by freezing. The old idea that tile should be porous has been abandoned.

The use of lumber box drains has been described in the preceding pages in connection with the experiments in Emery and Washington counties. Stone box drains have not been used to any extent in these districts so far as known, but brush and loose rock drains have been observed to fail by filling with sand and silt.

If farm drains must be laid along lines of water-loving trees and within 100 feet of them, the drains should be open ditches to prevent roots from obstructing them. The need of covered drains in orchards requiring drainage has necessitated a method of removing the roots without removing the tile. In California, cables are strung through the tile and root brushes pulled through short sections. A similar method was also employed in the Point Lookout experiment, as previously mentioned.

The questions of locating the lines and determining their sizes and depths will have to be determined by judgment, applying the fundamental principles herein stated. No general directions, such as a gridiron, double main, and single line or parallel systems, commonly used for drainage in humid districts, can be given for this kind of drainage. Such systems, with parallel lines 1 rod apart, might fail entirely if applied to some irrigated fields. If after careful examination the trouble is located as lateral seepage, a single line should be laid across the line of greatest slope 2 to 6 rods below the upper line of the wet spot. Such spots are usually small and one line may be sufficient, but an outlet line or branch should be laid through the low ground or basin. The distance down the slope affected by a drain will vary from 300 to 2,000 feet, according to local conditions. If the source is found to be in particular spots, as at Huntington, Emery County, a branch for each spot will be necessary. Wells as outlets for water-bearing porous substrata should be located at the end of the pocket if it pinches out, and on the lowest ground if it extends all the way under the tract.

Lateral and main outlet drains should be clear to a depth of 5 feet, especially if they are intended for farm outlets on such land. The depth of covered drains for arid soils is determined by two factors. The first is the depth of the drained soil necessary for different crops. For grasses and cereals a soil depth of 3 feet is sufficient. Fruit trees and alfalfa should have from 5 to 6 feet, and still greater depths are advantageous. The other factor in alkaline lands is capillary attraction. The height to which water will rise and evaporate in large quantities is the minimum depth allowable for ground-water level. Generally the water should be kept from 4 to 6 feet below the surface to satisfy these requirements. The minimum grade is 0.1 per cent and may be increased to as much as 5 per cent if necessary. Sizes from 4 to 6 inches will be sufficient for laterals in clay soils, with larger sizes for coarser soils. A study of the plans given in this bulletin will show that fewer drains are needed in the irrigated sections than in the humid.

Plans for drainage other than small inexpensive lines should always include surveys. Level surveys, both preliminary and final, are absolutely necessary. The need of surveys for expensive tile or open ditch work ought not to be questioned. The enormous losses to farmers and cooperative companies in the past, when constructing irrigating works without competent engineering supervision, should be a lesson, and similar mistakes should not be repeated in undertaking expensive drainage works. At the time when final surveys are made the lines should be tied up to or located with reference to permanent marks, and a map of the system made. Such a map may prove valuable in planning future extensions and in other ways, when otherwise the exact location would be forgotten.

FIELD CONSTRUCTION.

The tools most used for digging trenches are trenching spades, shovels, and tile scoops. Tile trenching machines are being introduced, but the chief dependence for this work will be hand labor. The digging for farm drains should always begin at the outlet, finishing the work as it proceeds, except completing the back filling. For trenches not deeper than 5 feet and for sizes of tile up to 12-inch, the top width need not be more than 18 inches. To insure proper alignment one side should be lined for the first spading. The last 16 inches should be removed in the last spading and the bottom graded at the same time. The work is much more easily done this way than if the digger were lower in the trench, and the bottom will remain firmer if not mushed up by constant tramping. Very few trenches can be finished in the irrigated districts without the trouble caused by the banks caving in, so that it is necessary to keep the tile laid and the trenches partly back filled up to within a few feet of the finished trench, and for that reason two or three diggers with one tile layer make the best team. With proper care the grade should only vary within one-fourth inch of true grade.

Laying tile is an important part of the proper construction of drains, even when the trench is made straight and on a uniform grade. The first item of importance is providing a firm foundation on which to lay the tile. In irrigated lands there are often soft spots which need some special treatment. The best method in such cases is to lay long boards in the trench upon which to lay the tile. If some such precaution is not taken one or more tile may settle or be pressed out of alignment and form a complete obstruction. When laying tile through an orchard with the intention of operating a brush or root cutter, boards with cleats on each side to hold the tile in true alignment are sometimes used. Tiles are not always cut off squarely, and when laid they should be turned until the tops set closely together, leaving the bottoms open for water. The ground should be firm enough to hold a man on a blinded tile, and the tile layer should work from the tile, if need be. Tile should always be carefully covered or blinded, as it is called, as soon as it is laid; and, for safety, the trench should be back filled enough to prevent the banks from caving in. Sand-trap boxes, as described in the experiment at Garland, Boxelder County, should always be put in at intervals of 300 to 500 feet, when fine sand or silt troubles occur, and also in orchards. These may be used as inlets for water when flushing tile or boxes.

After the tiles have been blinded and the trench partly filled by hand, the balance of the filling may be done with horses and plow. Three horses and a long evener are used for the first plowing. This plowing should be from the edges of the trench, after which a team may be used, one horse walking in the trench. It is not necessary to fill loosely so that the water may get into the tiles. Tramping and tamping are necessary to prevent surface water from entering and doing much damage. For the same reason, all brush and weeds should be removed, and not used for filling. The plowing should be continued until a heavy back furrow is worked up over the line.

SUBSEQUENT CARE NECESSARY.

Attention to drainage should not cease when the system is installed. Upon the subsequent care and treatment of the drains and drained fields will depend the final efficiency. One of the greatest sources of trouble, in covered drains especially, has been the damage resulting from surface water running into the trench. In some soils it has been necessary to place boxes or flumes for carrying irrigation water over trench lines to keep the water from finding its way down through the loose soil to the drain with resultant obstructions. These troubles occur in sandy and silt loams but not in clay loams. Tree and brush roots cause much trouble by growing into covered drains in search of water, and then developing enough water roots to seriously interfere with the flow of water. Alfalfa roots will also cause obstructions in tile after several years, and the report of the Hyde Park experiment (Cache County) contains an account of serious troubles caused by beet roots. To prevent excessive evaporation the proper cultivation of the surface is necessary. As explained before, a hard, smooth surface increases the evaporation of soil moisture. Where possible such soils should be cultivated after each irrigation so as to form a mulch on the surface. Shade crops, such as alfalfa, are also useful in preventing evaporation. Cropping and copious irrigation are absolutely necessary for reclaiming alkalied lands after underdrainage is supplied.

SUMMARY.

(1) The extent and value of lands in the arid West needing drainage make this a question of great importance. Most of these lands once produced abundant crops, but now they lie idle or produce only a small portion of what they should. Nearly every agricultural district in Utah, Washington, Montana, Wyoming, Colorado, and California has large areas in this condition.

(2) The value of understanding the fundamental principles of drainage, in preventing the increase of such conditions and reclaiming those lands now affected, can hardly be overestimated. Millions of dollars would have been saved in the West if the injurious results of seepage water and alkali and the methods of preventing them had been known and appreciated. Some knowledge of the nature and source of alkali, together with its relation to crop production, is essential. The reports of experiments in Utah, Washington, California, and Colorado, contained in this bulletin, afford proof that such injuries could have been prevented at a reasonable cost.

(3) Success is dependent upon correct plans and proper construction of drains. Careful and systematic surveys and subsoil examinations should never be omitted. The form of drain or section of

ditch should be chosen with reference to its efficiency in the particular soil formation and water conditions.

(4) The subsequent care and treatment of drains and lands will also determine the ultimate success. In humid countries drainage systems, once well laid, take care of themselves and usually operate successfully for many years. Drainage systems in arid countries, where irrigation is practiced, require watching and treatment after they are laid. The care is necessary in relation to surface waters, and the treatment of lands necessary when they are affected with alkali.

(5) The cost of draining the lands described in these investigations is the basis for the statement that such lands can be profitably drained. The Hyde Park lands, formerly only fit for pasturage, were drained at a cost of $15.60 per acre. During the two following years different portions were planted to oats, wheat, and sugar beets. The yields were 100 bushels of oats, 50 bushels of wheat, and 18 tons of sugar beets per acre. The Garland wet land was drained at a cost of $16.87 per acre, which raised the land value from less than $100 to $150 per acre.

The Getz farm at Point Lookout, which was badly alkalied and produced practically nothing, was drained, producing 35 bushels of oats per acre the following season. The Hobson farm at Roy, Utah, was drained at a cost of $13.67 per acre, which enhanced its value $25 per acre. The Richfield tract is well drained at a cost of $14.02 per acre, and the land, formerly worth $25 per acre, promises to reach the $100 mark. Lands in Weber and Davis counties, valued at $150 to $300 per acre, have been preserved by draining at about the same cost as those above mentioned. The Huntington and St. George tracts are not yet reclaimed, but it is expected that the cost of reclaiming such lands, according to methods now in use, will fall within or close to the highest costs given here.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued October 7, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 372.

SOY BEANS.

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C. V. PIPER,
Agrostologist in Charge,

AND

H. T. NIELSEN,
Scientific Assistant, Forage Crop Investigations,
Bureau of Plant Industry.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 30, 1909.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin, to supersede Bulletin 58 of the same series, the accompanying manuscript on "Soy Beans," prepared by Prof. Charles V. Piper, Agrostologist in Charge, and Mr. H. T. Nielsen, Scientific Assistant, Forage Crop Investigations.

The soy bean has become a crop of special importance in several Southern States, and interest in it has greatly grown during the past few years. At the present time there is great interest in the crop owing to the possibility that it may be grown on an extensive scale in regions where the boll weevil has rendered the returns from cotton culture uncertain. The recent enormous exportations of soy beans and soy-bean meal from Manchuria to Europe would seem to indicate that there is practically an unlimited market for this product. It is now believed that by the selection of proper varieties, of which the number is very large, the soy bean can be profitably grown in practically all parts of the cotton belt as a grain crop.

It is especially desirable to publish this bulletin at the present time in order that the possibilities of the crop may be generally understood.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction.......... 5
Climatic and soil requirements of soy beans.......... 6
Varieties of soy beans.......... 7
    Mammoth (yellow).......... 7
    Hollybrook (yellow).......... 9
    Ito San (yellow).......... 9
    Guelph (green).......... 10
    Buckshot (black).......... 10
    Ogemaw (brown).......... 10
    Wisconsin Black.......... 10
    Wilson (black).......... 10
    Meyer (mottled black and brown).......... 11
    Austin (greenish yellow).......... 11
    Haberlandt (yellow).......... 11
    Riceland (black).......... 11
The culture and planting of soy beans.......... 11
The inoculation of soy beans.......... 12
Soy beans for hay.......... 14
    Curing the hay.......... 15
Soy beans for pasturage.......... 15
Soy beans in mixtures.......... 16
    Soy beans and cowpeas.......... 16
    Soy beans and sorgo.......... 17
    Soy beans and millet.......... 17
    Soy beans and corn.......... 17
Soy beans for ensilage.......... 18
Soy beans for grain.......... 18
Soy beans in rotations.......... 20
Feeding value of soy beans.......... 20
    Feeding value for sheep.......... 20
    Feeding value for dairy cows.......... 21
    Feeding value for hogs.......... 22
Storing soy-bean seed.......... 22
Comparison of soy-bean grain and cotton-seed meal.......... 23
Comparison of soy beans and cowpeas.......... 24
Summary.......... 25

liability of spreading weeds and dangerous plant diseases. Successful inoculation by this method is, however, practically certain.

The method of inoculation by means of the pure cultures prepared by the United States Department of Agriculture is fully described in Farmers' Bulletin 315. Fresh liquid cultures are sent out in sealed bottles, and for small quantities of seed the culture may be diluted and used directly upon the seed. Directions and material for increasing the culture are supplied if a larger quantity is desired. The advantages of the artificial cultures lie in the greater ease of transportation and application, as well as in the absence of the danger of introducing plant diseases or harmful weeds. This method is frequently unsuccessful with soy beans, due possibly to the oily nature of the seeds.

When growing soy beans or any of the legumes for the first time it is an excellent plan to plant a small experimental plat, inoculating thoroughly by the pure-culture method. If this plat is successful, an abundance of soil will be available for inoculating large fields without danger of introducing weeds or diseases.

SOY BEANS FOR HAY.

Soy-bean hay when cut at the proper stage of growth and carefully cured is excellent, and for dairy cattle at least yields results equal to alfalfa hay. For hay production soy beans may be planted in cultivated rows, or when the ground is free from weeds they may be drilled or broadcasted. The late or medium-late varieties are as a general thing best adapted for hay production. These varieties grow to a greater height and have finer stems and branches and more leaves than do the earlier sorts. Of the varieties now handled by seedsmen the best for hay production are the Mammoth and the Ito San. The Mammoth variety makes a very large growth of plant, usually produces a large quantity of seed, and is well adapted for growing in the entire South. The Ito San is smaller, with finer stems, and also yields satisfactory crops of grain. It is at least a month earlier than the Mammoth.

Soy beans are not as a rule to be recommended as a hay crop north of the Ohio River, except in southern Illinois. The reasons for this are the shorter growing season, which tends to encourage the production of seed at the expense of plant growth, and the general culture of red clover, with which soy beans can scarcely compete in the production of hay. To get the best hay from soy beans they should be cut when half or more of the pods are fully grown, but before they begin to change color in ripening. Another rule, which is probably the better one to follow, is to cut when the top leaves begin to turn yellow. This is the best guide in most cases, but does not always apply, as some varieties, notably the Guelph, shed their leaves without change of color. At this stage of growth the largest yield and at the same time a good quality of hay will be secured. If the cutting is done earlier than this, the percentage of protein will be higher and there will be practically no waste in feeding; but the total yield will not be so large and the difficulty of curing much greater. If the cutting is much later than this, the total food constituents will be greater, but there will also be considerable waste of material in feeding due to the stems becoming hard and woody.

CURING THE HAY.

The planting should be timed, so that the crop can be cut for hay in September, as this month is usually the most satisfactory for haymaking. The cutting may begin as soon as the dew is off the plants and continue for the rest of the day. The plants should be allowed to lie in the swath until the leaves are well wilted, but great care should be exercised to rake them before the leaves become dry and brittle. After raking into windrows they should be left for a day or two, depending on the weather, and then put in small cocks or bunches. Three to five or six days of good weather is ample time for making good soy-bean hay. Great care should be used to prevent the loss of leaves, since these are the most valuable part of the plant except the pods.

When the hay is dry, it should be put in good-sized stacks or under a shed. If it is stacked in the open field it is very essential that some other material, either grass or a canvas cover, be put over the stack, as soy-bean hay does not shed rain well. Yields of from 1 to 3 and occasionally 4 tons of cured hay to the acre are secured. The average yield is about 2 tons per acre.

Curing frames can often be used to good advantage in making soy-bean hay, especially in unfavorable weather. The object of these frames is to keep the cocks open, so as to prevent matting and to allow the circulation of air. They are usually three or four sided pyramids made of boards or poles 3 to 6 feet long, fastened together at the top and held by crosspieces near the base. By this device a hollow cock or shock is secured, and consequent better curing.

In stacking the hay, poles or logs placed in the center of stack, so as to leave passages for air, will greatly lessen the danger of spoiling.

SOY BEANS FOR PASTURAGE.

The soy-bean crop can often be profitably utilized by pasturing, particularly to hogs, especially when fed corn in addition. This is advisable when harvesting is interfered with by lack of labor, bad weather, or other causes and when the crop is grown especially for soil improvement. By this means not only is the crop profitable in

ILLUSTRATIONS.

Page.
FIG. 1. Typical soy-bean plant........ 5
2. A plant of the Mammoth variety of soy bean, showing its characteristic habit of growth........ 6
3. Seeds and pods of seven varieties of soy beans........ 8
4. A field of the Mammoth variety of soy bean in North Carolina........ 9
5. Roots of a plant of the Mammoth variety of soy bean, showing characteristic nodules........ 13
6. A bunching attachment on an ordinary mower........ 19

B. P. I.—49

SOY BEANS.

INTRODUCTION.

The soy bean, also called the "soja bean" (fig. 1), is a native of southeastern Asia and has been extensively cultivated in Japan, China, and India since ancient times. Upward of two hundred varieties are grown in these countries, practically every district of which has its own distinct varieties. The beans are there grown almost entirely for human food, being prepared for consumption in many different ways. Their flavor, however, does not commend them to Caucasian appetites and thus far they have found but small favor as human food in either Europe or America.

As a forage crop, however, soy beans have become of increasing importance in parts of the United States, especially southward. They have been tested at most of the State agricultural experiment stations, and it is clear that their region of maximum importance will be south of the red-clover area and in sections where alfalfa can not be grown successfully. They thus compete principally with cowpeas, but as cultiva-

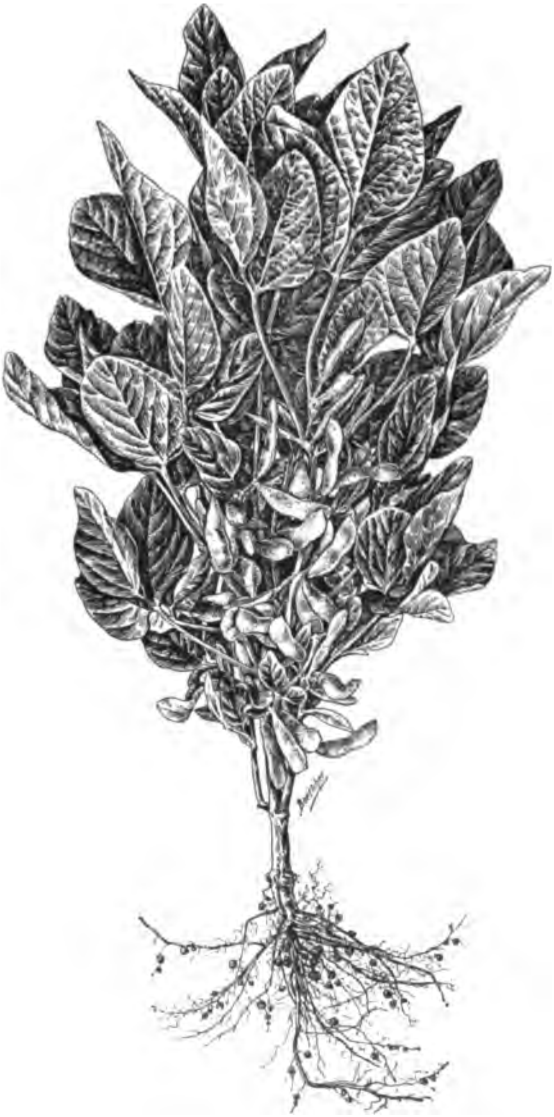

FIG. 1.—Typical soy-bean plant.

SOY BEANS FOR ENSILAGE.

The growing of soy beans for ensilage has not been practiced very extensively. In a number of instances ensilage has been made of the crop, usually in combination with corn, and it is invariably reported as making an excellent succulent feed. Only the larger late-growing varieties are desirable for this purpose. Some have tried growing soy beans in the corn rows or between the corn rows, planting them the same as cowpeas are planted in the cornfields of the South, while others prefer growing corn and soy beans in separate fields and when the ensilage is put up to mix them in the cutting. Where the soil and climate will permit, it would seem to be more satisfactory to grow the soy beans in the cornfield. It is doubtful whether it will be economical to make ensilage of soy beans when hay can be made with comparative ease. Corn deteriorates so much more rapidly in the shock than do most of the crops which can be made into hay that if ensilage is to be made on the farm the more economical practice will likely be to use the corn crop for this purpose and save the other crops for hay.

SOY BEANS FOR GRAIN.

Growing soy beans for the grain for use as feed is distinctly profitable if the yield is 16 bushels or more per acre. The feeding value of the grain is very high, being slightly superior to cotton-seed meal. The grain is rich in protein, while nearly all the other grains produced on the farm are poor in protein, but rich in carbohydrates.

For grain production tall varieties that do not branch or bear pods close to the ground are desirable, as they are more easily harvested. Of the varieties now on the market the Mammoth and Hollybrook are undoubtedly much the best for the South, while the Ito San and the Guelph, which is also known to the trade as Medium Green, are best for more northerly latitudes. A very serious objection to the Guelph, however, is its great tendency to shatter seeds at ripening time.

When grown for grain alone, the cutting may be delayed in the case of most of the varieties until all of the leaves have fallen. The Guelph and a few other varieties not on the market retain the leaves late and much seed would be lost by shattering if the harvesting were not done earlier. The plants should be allowed to become thoroughly dry after cutting before they are stacked or put into a barn or shed. Care should be taken, however, not to let them get too dry before they are piled into bunches, as there is likely to be considerable shattering of seed in such cases, especially if rained upon.

varieties are apt to make a large plant growth and a comparatively small yield of seed, and on the poorer soils a small plant growth with a relatively large seed yield.

Soy beans do not require a well-drained soil for their best development, although they will not grow in a soil where water stands for any considerable length of time. However, they are able to withstand a greater amount of moisture than either corn or cowpeas. In eastern North Carolina on the vegetable mold soils they make excellent crops. On this account soy beans are especially valuable for growing in that region, since the heavy rainfall is the main drawback.

Soy beans are also decidedly drought resistant, much more so than cowpeas, and but for the depredations of rabbits would be a valuable crop in the semiarid West. Rabbits are exceedingly fond of the foliage, and where they are numerous it is nearly useless to plant soy beans unless the field can be inclosed with rabbit-proof fencing.

VARIETIES OF SOY BEANS.

At the present time seven varieties of soy beans, Mammoth, Hollybrook, Guelph, Ito San, Buckshot, Ogemaw, and Wisconsin Black, are handled by American seedsmen. (See fig. 3.) During the past three years more than two hundred additional varieties have been introduced from China, Japan, and India, most of which have already been sufficiently tested to give some idea of their value. Many of the new varieties are so superior in various respects that they are certain to replace all of the above-named varieties except the Mammoth and, perhaps, the Ito San.

The matter of variety is of special importance in soy beans, as many growers have been sorely disappointed in getting a small early variety when they desired a larger and later sort. As this difficulty occurs when there are at most seven varieties handled by seedsmen, it can readily be seen that there is the possibility of greater confusion with the introduction of more varieties. On this account it is very desirable to keep down to the minimum the number of varieties introduced into the seed trade, and these the very best sorts. Seedsmen are urged to use the varietal names here adopted, and buyers should be very careful to specify the variety wanted.

MAMMOTH (YELLOW).

The Mammoth variety (see figs. 2, 3, 4, and 5) is the largest growing and latest of the soy beans at present handled by seedsmen. Under average conditions it will grow from 3 to 5 feet high, depending principally on the character of the soil. (See fig. 4.) Ordinarily it requires from 120 to 150 days to mature a crop of seed. The Mammoth yields well in both grain and roughage and is satisfactory

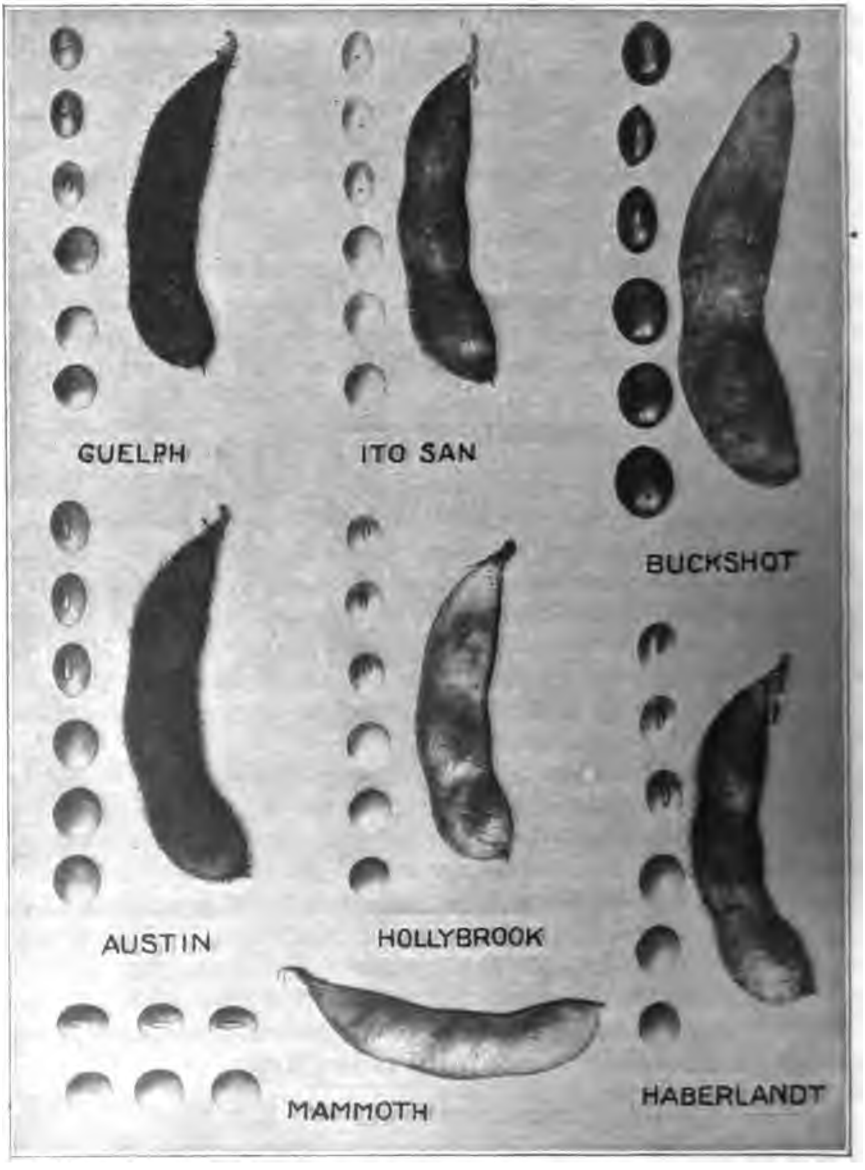

FIG. 3.—Seeds and pods of seven varieties of soy beans. Natural size.

for both. It is a most exacting variety about depth of planting, and under no circumstances should the seed be planted more than 2 inches deep. The habit of growth is such that it can readily be harvested with machinery and it is frequently gathered with a grain binder. It is well adapted to nearly all of the country south of the northern boundary of Tennessee and can be grown quite successfully some distance north of this, though not as far north as Washington, D. C.

HOLLYBROOK (YELLOW).

The Hollybrook variety is about two weeks earlier than the Mammoth and seldom grows to a greater height than about 3 feet. It is very coarse and woody and therefore not desirable for hay, but it yields large crops of grain. The seed is very nearly identical with that of the Mammoth. The lower branches and pods are apt to be very near the ground, and there is consequently some difficulty in harvesting this variety. It can be grown farther north than the Mammoth, but is not nearly so valuable a variety.

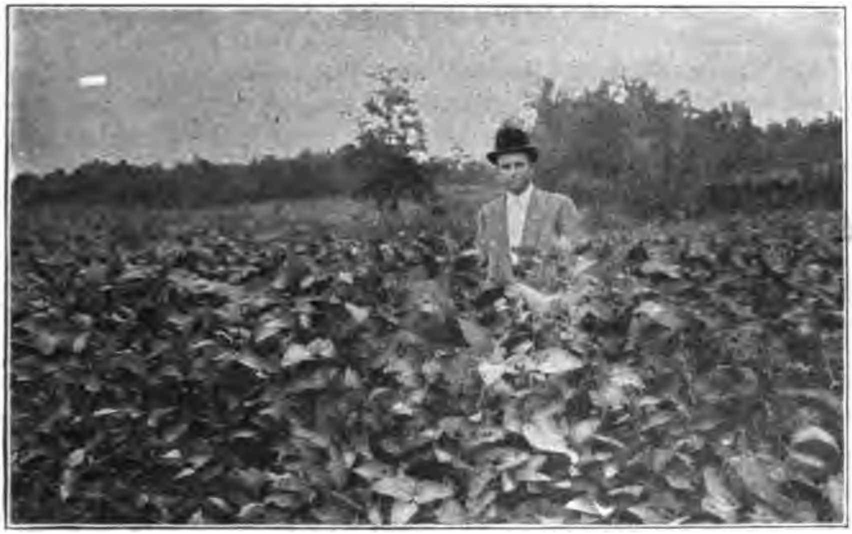

FIG. 4.—A field of the Mammoth variety of soy bean in North Carolina.

ITO SAN (YELLOW).

The Ito San soy bean has been very commonly grown, appearing under the names "Yellow," "Early Yellow," "Medium Yellow," and "Early White," as well as "Ito San." The plants are of medium size, averaging about 30 inches in height, with numerous ascending slender branches, so that this variety can be mown very satisfactorily. It has fine stems and makes excellent hay, though the yield is only moderate. It produces seed fairly well and matures in from 95 to 100 days. It is a very satisfactory variety to grow in a short season or after a small-grain crop. The seed, which is about the same size as that of the Mammoth, can always be identified by a little brown speck at one end of the hilum, or seed scar. This variety will mature as far north as southern Wisconsin and southern Michigan.

GUELPH (GREEN).

The Guelph soy bean has been advertised more than any other variety, appearing with such names as "Medium Green," "Medium Early Green," and "Large Medium Green." It grows about as large as the Hollybrook variety and matures about 10 days later than the Ito San. The leaves drop without changing color when the plant ripens. The plant is very coarse and not satisfactory for hay. While the seed yield is heavy the pods shatter very much. On these accounts the Guelph is not a desirable variety.

BUCKSHOT (BLACK).

The Buckshot is a very early variety, which has been handled by northern seedsmen. It is also called "Early Black," "Extra Early Black," "Medium Early Black," and "Large Black." It seldom grows more than 24 inches high and is at least a week earlier than the Ito San variety. The seed is considerably larger than ordinary buckshot, but has the same shape. The plants are entirely too small and coarse and produce pods too near the ground to be of much value. If the Buckshot variety is planted at all it should be only in the northern tier of States.

OGEMAW (BROWN).

The Ogemaw is even earlier than the Buckshot variety, and is also a smaller grower and less satisfactory. The seed, which is about the same size as that of the Buckshot variety, can sometimes be purchased from northern seedsmen.

WISCONSIN BLACK.

The Wisconsin Black is an early black-seeded variety that is grown to some extent in Wisconsin and Michigan. Its earliness is its principal merit.

The following new varieties are the best out of more than one hundred sorts tested. They are not yet in the market, but most of them will be available in 1910.

WILSON (BLACK).

The Wilson is a tall variety, growing 3 to 4 feet high, with few erect branches, maturing about one week later than the Ito San. Owing to its tall habit and lack of basal branches it can be harvested easily. It is a heavy grain yielder and also excellent for hay. This variety should be very valuable in such States as Illinois, Indiana, and Ohio, replacing the Guelph variety especially.

MEYER (MOTTLED BLACK AND BROWN).

The Meyer variety is excellent for hay, as it is tall and has fine stems and branches. During the past three years it has given larger yields of seed than any other variety under trial at the Arlington Experimental Farm in Virginia. Its tall habit makes it easy to mow, but unfortunately it is somewhat inclined to lodge. It matures in 110 days. The seeds are large and break rather easily in thrashing.

AUSTIN (GREENISH YELLOW).

The Austin is a vigorous though not coarse medium-late variety, growing 3 to 4 feet high, with numerous branches but none close to the ground. It can be easily harvested with machinery and is an excellent seed producer.

HABERLANDT (YELLOW).

The Haberlandt variety requires about one week's more time in which to mature than does the Ito San. The seed is considerably larger than that of any of the other yellow-seeded varieties and has a distinctly brown hilum, or seed scar. It is a very heavy yielder of seed, but is rather stocky, seldom growing to a greater height than 30 inches. It can be harvested fairly well with a mower and will give better results than the Ito San variety in many places. Under the conditions in Tennessee it has proved very satisfactory and is strongly recommended there when an earlier variety than the Mammoth is desired.

RICELAND (BLACK).

The Riceland is a soy bean which requires a very long season in which to make its full development, and is therefore adapted only to the cotton belt. The seed is rather small, long, and flat, and covered with a powdery bloom which makes it look dusty. The plants grow from 4 to 6 feet high, but have fine stems and consequently are of a very desirable type for hay.

THE CULTURE AND PLANTING OF SOY BEANS.

Good preparation of the soil is necessary for soy beans; otherwise weeds are likely to choke out the young plants. This preparation should consist of deep plowing and subsequent working with disk and harrow until a firm seed bed, with the upper 2 or 3 inches loose and mellow, is secured. Under nearly all conditions the crop should be grown in rows and given sufficient cultivation to keep down weeds. If the ground is exceptionally free from weeds soy beans may be sown broadcast or drilled with the idea of using them for hay. The yield of seed is nearly always greater when grown in cultivated rows.

Soy beans if in rows should be planted so as to have a plant on an average of every 2 or 3 inches in the row and the rows from 30 to 36 inches apart. Cultivation can be more easily accomplished if the rows are 36 inches apart than where the distance is less, though the plants have room for development in 28-inch rows. In eastern North Carolina soy beans are planted in rows 4 feet apart and hilled as high as possible to aid in drainage, which is very important in that region.

It is especially important to plant seed of good quality. Soybean seed unless it is fresh and has been properly stored is very apt to be low in germination. It should therefore be tested for viability before planting time. The planting should be shallow, preferably 1 inch and not to exceed 2 inches in depth. Poor stands result more frequently from too deep planting than from any other cause. A bushel of good seed is sufficient to plant from 2 to 3 acres if in cultivated rows, and hardly enough for 1 acre if sown broadcast.

The cultivation of soy beans is a simple matter. Unless conditions are very unfavorable the seedling plants appear above ground in a week and tillage may then begin. Any good cultivator may be used, and flat cultivation is preferable, as the harvesting can be more easily done than if the rows are hilled or ridged.

Soy beans may be planted through a wide period from early spring till midsummer. Ordinarily they are planted about June 1. In the lowlands of Tennessee and North Carolina and southward two crops of the early and medium varieties may be secured in a season. In general, early plantings require more time to mature than late plantings, the difference in the same variety often amounting to as much as three weeks.

THE INOCULATION OF SOY BEANS.

Like other legumes, soy beans are able to utilize the nitrogen of the air and add it to the soil by means of root nodules. These nodules (fig. 5) are caused by certain bacteria; unless they are present soy beans in the usual types of soil will make but a weak growth, and many of the plants will turn yellow and die.

Throughout the South the proper bacteria for soy beans seem to be widely distributed, so that natural inoculation now occurs generally. In isolated localities where this crop has not been grown, however, some difficulty may be expected from lack of inoculation during the first season at least. Northward and westward greater difficulty in this regard is experienced.

Inoculation of a new field may be secured either by the soil-transfer method or by the use of the pure cultures prepared by the Department of Agriculture. The soil-transfer method consists in scattering soil from an old, well-inoculated soy-bean field over the new ground at the rate of 200 to 300 pounds per acre. To facilitate even scattering this should be thoroughly mixed with several times its weight of ordinary soil. The soil may be either drilled or broadcasted. In the latter case it should be done toward evening or on a cloudy day, as bright sunshine is very harmful to the germs. The objections to the soil-transfer method are the labor and cost involved and the serious

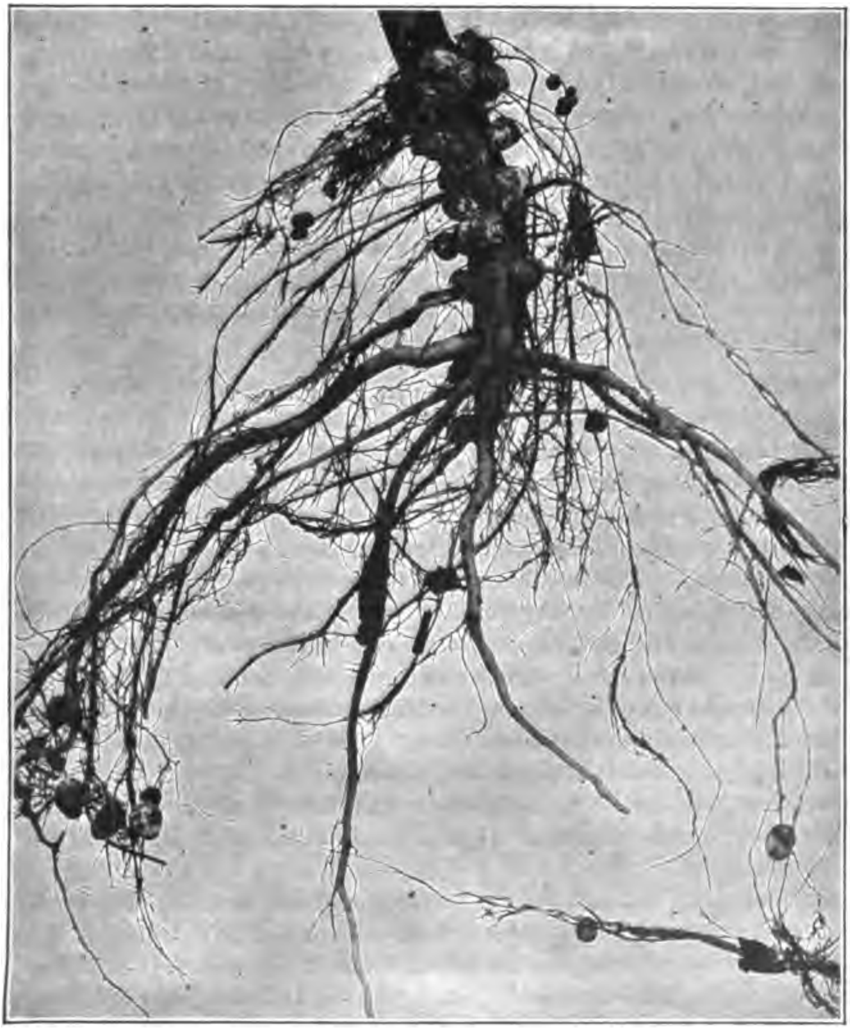

FIG. 5.—Roots of a plant of the Mammoth variety of soy bean, showing characteristic nodules.

exceed 2 inches in depth, and preferably in rows 30 or, better, 36 inches apart to permit sufficient cultivation to keep down weeds.

(10) For harvesting soy beans a mower with or without a side-delivery attachment, a self-rake reaper, or a self-binder can be used. A binder can be used only with the tall varieties. The thrashing can be done with a grain separator by using blank concaves and running the cylinder much slower than for small grains or by the use of machines specially designed for handling soy beans and cowpeas.

(11) Soy beans and cowpeas can be grown together satisfactorily; the hay of such a mixture is better than either crop alone and the yield is generally greater. In planting the two together the seed should not be covered too deeply, as deep planting will result in a poor stand of soy beans.

(12) As a crop in a short rotation soy beans are very desirable. They can be grown so as to use an entire season in the case of the late varieties, or two crops in one season can be secured from some of the earlier ones. They can also be used very advantageously to follow a small-grain crop the same season.

(13) The important commercial varieties of soy beans are the Mammoth, the Hollybrook, and the Ito San. Among the most valuable new varieties are the Austin, the Wilson, the Riceland, the Meyer, and the Haberlandt, most of which will be in the hands of seedsmen in 1910.

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Issued November 19, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 373.

IRRIGATION OF ALFALFA.

BY

SAMUEL FORTIER,

Chief of Irrigation Investigations, Office of Experiment Stations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., July 15, 1909.

Sir: I have the honor to transmit herewith material for a bulletin on the irrigation of alfalfa, prepared by Samuel Fortier, chief of irrigation investigations of this Office. This material is based on the best irrigation practice of the arid region, and is intended primarily for the use of settlers under the large canal systems now under construction. It is therefore recommended that it be published as a Farmers' Bulletin.

Doctor Fortier wishes to acknowledge the receipt of notes on the irrigation of alfalfa from the following State agents and special agents temporarily employed by them for this and other purposes: Arizona, C. E. Tait, in charge, and C. G. Gillespie, special agent; California, F. W. Roeding, in charge, and R. C. Benson, Paul Baily, and Lee O. Murphy, special agents; Colorado and Wyoming, O. W. Bryant, in charge, and Fred J. Barnes, C. M. Wood, A. B. Collins, and George C. Kreutzer, special agents; Idaho, Elias Nelson and John Krall, special agents; Kansas, Don H. Bark, in charge; Montana, H. I. Moore, special agent; Nevada, Gordon H. True, in charge, and F. L. Peterson, special agent; New Mexico, B. P. Fleming, in charge; Oregon, A. P. Stover, in charge; Utah, W. W. McLaughlin, in charge, and L. M. Winsor, special agent; Washington, S. O. Jayne, in charge.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction........ 7
Irrigable lands adapted to alfalfa........ 8
The removal of native vegetation........ 10
Preparatory crop........ 12
Methods of irrigating alfalfa........ 13
    The border method........ 13
    The check method........ 16
    The flooding method........ 20
    The furrow method........ 25
Farm ditches........ 31
The subirrigation of alfalfa fields........ 35
The amount of water required........ 38
The proper time to irrigate alfalfa........ 40
Winter irrigation of alfalfa........ 41
Winterkilling of alfalfa........ 41
Seeding alfalfa on land to be irrigated........ 43
Rise of ground water and its effects on alfalfa........ 44
The injurious effect of silt on alfalfa and the benefits to be derived from disking. 46
Pasturing irrigated alfalfa........ 46
Production of alfalfa seed under irrigation........ 47
Profits to the irrigator........ 47

ILLUSTRATIONS.

Page.
Fig. 1. Soil auger........ 9
2. Sagebrush grubber used in clearing land near Riverton, Wyo........ 11
3. Levee smoother made by H. I. Moore........ 14
4. Adjustable ridger........ 15
5. Carpenter's spirit level attached to a tripod........ 17
6. Laying out rectangular checks on farm of T. K. Beard, Modesto, Cal.. 18
7. Grader........ 19
8. Laying out contour checks........ 19
9. Scraper........ 21
10. Leveler used in Gallatin Valley, Montana........ 22
11. Homemade drag or leveler........ 23
12. Preparing land for flooding in Montana........ 23
13. Flooding from head ditches in northern Colorado........ 24
14. A 20-acre alfalfa field near Berthoud, Colo., showing supply lateral, field laterals, contours, and waste ditches........ 25
15. Outlines of percolation from furrow 5 inches deep in seven hours.... 26
16. Buck scraper........ 26
17. Showing tract prepared for furrow irrigation........ 27
18. Manner of placing tubes in ditch bank for furrow irrigation........ 28
19. Furrower used on experiment farm, Riverton, Wyo........ 29
20. Check box for furrow irrigation........ 29
21. Building a supply ditch........ 30
22. A border gate used in Imperial Valley........ 31
23. Border gate used near Sunset City, Cal........ 32
24. Concrete gate used in Yolo County, Cal........ 32
25. Supply ditch with bottom width of 4 feet........ 32
26. Supply ditch with bottom width of 6 feet........ 33
27. "A" crowder........ 33
28. Adjustable "A" scraper or crowder........ 34
29. Lateral ditch with bottom width of 14 inches........ 34
30. Lateral ditch with bottom width of 16 inches........ 34
31. Lateral ditch with bottom width of 2 feet........ 34
32. One hundred and twenty-acre subirrigated farm of C. H. DeCamp, 12 miles south of St. Anthony, Idaho........ 37

IRRIGATION OF ALFALFA.

INTRODUCTION.

Experience in the growing of alfalfa for more than two thousand years shows that it thrives best in the soil and climate of arid and semiarid regions. The abundant sunshine, the warmth, and the deep, rich soil prevailing throughout the western half of the United States seem to be well suited to its requirements, and over half a century's experience has shown that there is comparatively little cultivable land in the West on which it can not be grown. One finds the same varieties flourishing in Imperial Valley, California, 100 feet below sea level, and maintaining a sturdy growth on the San Luis plains of Colorado, 7,500 feet higher. Alfalfa makes a remarkable growth in the warm sunshine of Arizona, yet it is rarely injured by cold in Montana.

One can not well overestimate the importance of alfalfa to western farmers. The alfalfa field and the alfalfa stack provide the best means of protecting stock against enormous losses by starvation when the excellent pasturage available throughout the greater part of the year fails either through drought in midsummer or by being covered with deep snow in midwinter. A single ton of alfalfa may save the lives of many head of stock by providing feed during short periods of cold, stormy weather. Alfalfa can not be excelled as a preparatory crop on soils that have long been unproductive. Likewise, it maintains the fertility of soils naturally rich in plant food, and if used as a base of rotation makes possible abundant crop yields of various kinds. In 1906 the chemist of the Colorado Experiment Station [a] estimated the fertilizing value of the stubble and roots of mature plants at $35 per acre when measured by the commerical value of artificial fertilizers on the market. Moreover, the yields are exceptionally high when irrigation, favorable climatic conditions, and proper treatment are combined. Seven tons of cured hay at three cuttings are obtained from the best fields of Montana, while frequently 9 tons in five cuttings are harvested in California. This large tonnage, together with its high feeding value and the fact that it is consumed by practically all farm animals, makes it not only a convenient and useful crop to the grower, but a highly profitable one as well.

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[a] Colorado Sta. Bul. 110.

Notwithstanding its present importance and great value in irrigation farming, the profits on the area now in alfalfa can be greatly increased if more care and skill are exercised in growing it. The western irrigator has seldom been able, financially, to dig his ditches and prepare his fields in such a way as to insure the most efficient irrigation and the highest profits. In consequence, valuable water is wastefully applied to land that is in no fit condition to be irrigated. On the large acreage in irrigated alfalfa this amounts to an enormous loss. This fact, considered in connection with the importance of this crop, the rapidly increasing area devoted to its growth, and the large number of farmers who are settling in the West and who will be for years dependent in a large measure on alfalfa for a livelihood, would seem to warrant the collection and publication of any information designed to improve the present practice.

As its title implies, this publication deals with but one feature, that of irrigation, and its scope is necessarily limited to irrigated lands. There has been no attempt to present or discuss at any length other phases of the general subject of alfalfa growing,[a] and wherever mention has been made of these it has been only to show their relationship to irrigation.

In the examination of alfalfa fields and the collection of the data necessary for this publication, advantage was taken of the organization of the irrigation investigations of this Office, which is well adapted for such a purpose. Through the State and Territorial agencies of that division and through cooperation with the members of State experiment stations and the State engineers it was possible to obtain with a high degree of accuracy the conditions and irrigation practice with reference to this crop throughout the entire arid region.

IRRIGABLE LANDS ADAPTED TO ALFALFA.

Perhaps the most essential conditions for the production of alfalfa are abundant sunshine, a high summer temperature, sufficient moisture, and a rich, deep, well-drained soil. All of these essentials, save moisture, exist naturally in the arid region of the United States, and when water is supplied it makes the conditions ideal. Although alfalfa can be successfully grown under a wide range of soil conditions, yet all western lands are not equally well adapted to its growth. For this reason those who are seeking such lands with a view to their purchase should first make a careful examination of the character and depth of the soil, its behavior when irrigated, the slope and evenness of the surface, the presence of injurious salts, and the facilities for drainage.

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[a] These are treated in U. S. Dept. Agr., Farmers' Bul. 339.

One of the best indications of the character of the soil is the native vegetation. When sagebrush, buffalo grass, or cactus is found on a tract it is reasonably certain that the soil is fertile, easily tilled, and well drained. On the other hand, the presence of greasewood, saltwort, salt weeds, or similar plants is indicative of a heavier soil, less easily cultivated and irrigated, and containing more or less of the injurious salts usually grouped under the common name of alkali.

In arid regions most cultivated plants are deep rooted. They draw their supply of plant food and moisture from considerable depths, and the deeper the soil the larger is the feeding ground for the roots and the greater is the capacity to store water. The presence of any impervious stratum lying between the first and fifth foot prevents deep rooting and the storage of moisture. A hard stratum lying between the fifth and tenth foot is likewise injurious, but to a less extent. The character of the subsoil may be readily determined by boring holes, with a suitable soil auger similar to that shown in figure 1, to a depth of 10 feet, if necessary, and taking samples of soil at different depths. It will be possible usually to find under irrigation in near-by fields soils similar to those being examined, but if this is not possible a trial may be made on a small scale to determine how the soil acts under irrigation. In general, sandy loams irrigate well; clay is hard to cultivate when wet, does not absorb water readily, and bakes and cracks when drying; while a soil which is too sandy will not retain sufficient moisture to maintain crops.

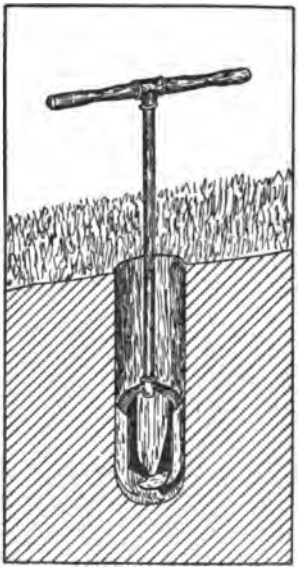
FIG. 1.—Soil auger.

The most favorable condition for irrigating is a smooth surface, with a uniform slope of 10 to 20 feet to the mile. Such land costs little to put into shape for the spreading of water over it, and the slope insures good drainage. Sometimes the land is cut up by ravines which increase the labor and cost of putting water upon it, or it may have too much or too little slope. In other cases it is full of buffalo or hog wallows which are difficult to bring to an even grade. If land which is naturally smooth on the surface and of the right slope costs $5 per acre to prepare for irrigating, hog-wallow land may cost $15. Besides, some hog-wallow land is inferior in quality, frequently being charged with injurious salts.

Lastly, good drainage is essential for a permanently productive irrigated farm. It is practically impossible to supply crops with sufficient water for the best growth without applying so much that some will seep into the subsoil. Unless this can flow away the level of the ground water will rise until it comes near the surface and drowns out crops, and perhaps cause an accumulation of alkali. If the natural drainage is not good it must be supplied artificially, but this need not be done until a few crops have been raised, for the reason that it is not possible to tell until after irrigation where the drains should be placed to drain the land most effectively.

The frequent failures to get a good stand of alfalfa in the humid portions of the United States have led some writers on this subject to prescribe within somewhat narrow limits where and under what conditions this forage plant can be grown successfully. That this view is not correct as regards the irrigated portion of the United States is amply shown by the fact that it is grown successfully in every State and Territory of the arid region, in localities which are not only widely separated but possess many radical differences in the way of rainfall, temperature, altitude, topography, and soil.

THE REMOVAL OF NATIVE VEGETATION.

In arid America few places are so barren as not to produce plants of some kind, and the first step in preparing land for irrigation is the removal of this native vegetation. When this consists of native grasses, low cacti, or small bushes they can be plowed under or removed without much extra expense, but when it consists of large sagebrush, mesquite, or greasewood, the cost is high and the task of removing it may require special implements. Of all the desert plants sagebrush is the most common. Formerly the grubbing hoe, or mattock, and plow were the only implements used to remove this bush. Breaking down the branches and then digging out the roots before attempting to plow proved laborious. By this process the cost of grubbing, gathering the brush into piles, and burning varied from $2 per acre in light sage to $5 per acre in heavy sage. Of late, farmers who are well provided with work teams greatly expedite the work and reduce the amount of manual labor by first dragging a railroad rail or heavy timber over the sagebrush. This work can be done best when the ground is frozen. If only two teams of two horses each are available, one rail will suffice, but with six, or, better still, eight horses, four at each end, two railroad rails may be bolted together. If iron rails can not be had, two large logs chained together make a good substitute. In railing brush, as it is termed, the rails are dragged at least twice over the same strip, but in opposite directions. The few stumps which remain are then grubbed out by hand or left to be plowed out and the brush raked into windrows and burned. A brush rake may be made of a 6-inch timber 12 feet long, by boring 2-inch holes through the timber, 10 inches apart, and inserting in each a wooden tooth about 3 feet long. The rake is then fastened by two joists to the rear of a wagon to which a team is hitched. In the San Joaquin and Imperial valleys of California the railroad rail is bent in the form of a V, but it is a question if this form has any advantages over the straight rail. A more effective implement for light brush is sketched in figure 2. From 8 to 12 horses are hitched to it and 20 acres may be cleared in one day. In Kern County, Cal., a 6 by 12 inch timber, 24 feet long, shod with steel, is preferred. The steel shoe projects about half an inch and a board on the back, similar to that of a buck scraper, serves to keep it in position. A team is hitched to each end, crossing the field and returning on the same track. The cost of the removal of sagebrush by means of teams and a minimum amount of hand labor runs all the way from $1.50 to $4 per acre, depending on the character and extent of the growth.

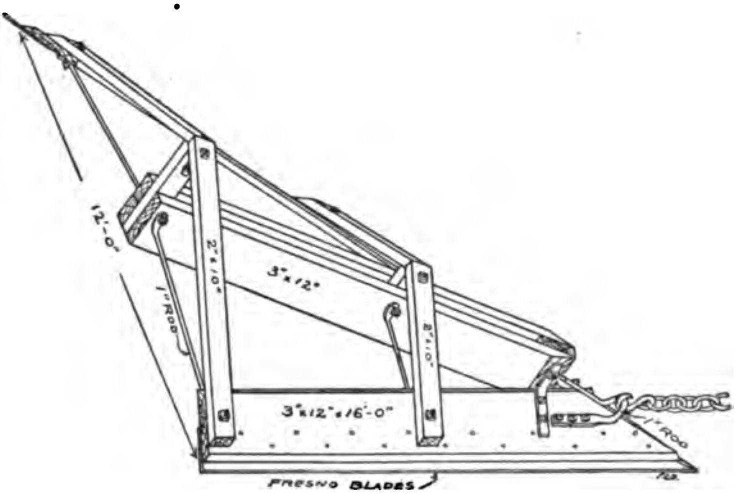

FIG. 2.—Sagebrush grubber used in clearing land near Riverton, Wyo.

In the Imperial Valley of California, the Rio Grande Valley of New Mexico and Texas, and in parts of Arizona, the mesquite tree is quite troublesome to remove. This usually has to be grubbed out by hand and the cost varies from $5 to $40 per acre, depending on the number and size of the trees. Oscar Snow has 600 acres in alfalfa in the Mesilla Valley, New Mexico. In its natural state the land was covered with a dense growth of tornillo, mesquite, and shad scale. He states that it cost him $40 to $50 per acre to cut the brush, grub out the roots, grade the land, and seed it to alfalfa.

The usual price paid for grubbing out mesquite bushes in Salt River Valley, Arizona, is 30 cents per tree and the cost may run as high as $100 per acre. The larger trees have usually some value as firewood and fence posts.

Mr. Hubbard, of Weiser, Idaho, rids the raw land of sagebrush and plows it to a depth of 8 inches before grading and leveling the surface. Whenever possible, this work is done in the fall, and early the following spring the tract is thoroughly disked and harrowed. He prefers flooding the tract before seeding in order that the water may show up the low as well as the high places and also to insure ample moisture for the speedy germination of the seed. When the surface dries out sufficiently to pulverize after the harrow, it is seeded. In this part of Idaho the cost per acre for removing sagebrush varies from $2.50 to $4; for plowing, $2.50 to $3; disking, 50 cents to 75 cents; harrowing, 35 to 50 cents. Grading and leveling are discussed under another heading.

In localities covered by native grasses, nothing more is necessary than plowing and thorough cultivation. The native grass lands of Montana are usually plowed 2 to 5 inches deep in the fall. In the spring the surface is double-disked, perhaps cross double-disked, harrowed, and leveled, and then seeded to grain rather than alfalfa, in order to properly prepare the surface of the ground for the later crop.

The cost of plowing new land in Kern County, Cal., where the surface is covered with low sage, wheat, and wire grasses, runs from $2 to $4 per acre, depending chiefly on the depth of plowing, which is usually more than 4 inches and less than 10 inches. On the extensive holdings of Miller & Lux traction engines are used to operate gang plows, followed by harrows. By this means, it is claimed, the cost can be reduced to between 75 cents and $1 per acre.

In all the older irrigated sections of the West alfalfa usually follows some other crop. If preceded by grain the stubble is first pastured, preferably by sheep, plowed in the fall to a depth of 7 to 10 inches, and then allowed to lie until the following spring, when it is disked, harrowed, and seeded.

PREPARATORY CROP.

Experience has shown that it is difficult in the course of six months or a year to secure a good stand of alfalfa on raw land that has been covered by a desert growth. This is true particularly of rough, uneven land on which crop rotation is not to be practiced. It is likewise true of land thickly covered with brush. It has been found impracticable in most localities to secure a smooth, well-graded surface where fresh roots interfere with the proper use of all grading and leveling implements. The same is true of hog-wallow land, where considerable soil has to be removed from the high places and deposited in the low places. It takes time and a second preparation of the surface before fields of this character can be put in good condition for the growth and irrigation of alfalfa. If crop rotation is to be followed the necessity for a preparatory crop is not so urgent, since the alfalfa will soon be plowed under to give place to another crop. In northern Colorado, where alfalfa usually follows either potatoes or sugar beets, the surface is not plowed, but merely harrowed or disked in the spring just before seeding. If the surface is uneven, it is smoothed and leveled by means of a float or drag before the seed is put in. In southwestern Kansas it is likewise considered best to plant alfalfa after some cultivated crop which has held the weeds in check. The land is plowed in the fall to a depth of 6 inches, double-disked in the spring after the weeds have started, and is subsequently harrowed. In the vicinity of Los Banos, Cal., new land is almost invariably sown to barley or corn for two seasons before seeding to alfalfa. In Utah wheat or oats is preferred as a preparatory crop. The chief purpose of all such preparatory grain crops is to allow fresh roots of the original plant covering to decay, filled-in spots to settle, high places denuded of the upper layer of soil to weather, and in general to prepare a well-pulverized seed bed in a smooth, well-graded field.

METHODS OF IRRIGATING ALFALFA.

The methods of applying water to alfalfa differ widely because of diversity in soils and subsoils, in climate and topography, in the nature of the water supply, the size of the farm, the amount of money available for preparing the land for water, the prevailing crops grown, and the early training and environment of the irrigator. The standard methods have been grouped under the following heads, namely, the border method, the check method, flooding from field laterals, furrow irrigation, and other less common methods, with various modifications of each.

In passing it may be said that the usual order is to locate and build the farm ditches first and prepare the land afterwards. In this bulletin it has been deemed best to describe the methods in use and then to consider the location and construction of farm ditches. After one has a general knowledge of the various ways of applying water and of the size and character of the ditches required for each method he is in a better position to understand the proper methods to adopt in building farm ditches. This subject will therefore be treated separately under its own heading.

THE BORDER METHOD.

Essentially the border method consists of the division of a field or tract into long, narrow strips or lands by low flat levees which usually extend in the direction of the steepest slope and confine the water to a single strip. The bed of each strip is carefully graded to a uniform slope, although the slope may change to conform to the contour of the natural surface. The water to irrigate each strip is taken from the head ditch extending across the upper edge of the field, and is controlled by an outlet box or border gate, although the gates are sometimes omitted to save in first cost of preparing for irrigation. Check gates, canvas dams, or metal tappoons are used to hold up the water in the head ditch to cause it to flow into the borders.

This method is confined chiefly to the irrigation of alfalfa and grain, and in its various modifications is used extensively in Arizona, California, and, to a less extent, in Idaho, Montana, and other Rocky Mountain States. It can be used best under canals which deliver water to users in large streams, since the smallest head that can be applied successfully is seldom less than 2 or 3 cubic feet per second, but heads of 5 to 10 cubic feet per second are the rule. It is adapted especially to light, open soils, into which water percolates rapidly, as the use of a large stream confined between borders makes it possible to force water over the surface without great loss by percolation.

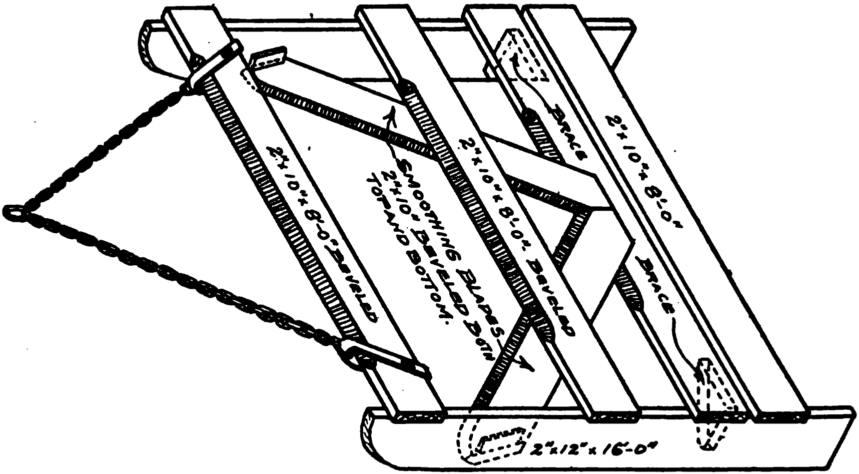

FIG. 3.—Levee smoother made by H. I. Moore.

On the university farm at Davis, Cal., the borders or lands average about 50 feet wide by 900 feet long. Each levee has a base 7 feet wide and is 12 inches high, when newly made, but settles to about 10 inches before the first crop is harvested. The bed of each strip is leveled crosswise and slopes regularly from top to bottom. In preparing the surface of this field, the barley stubble was burned, then the soil was disked and roughly graded. The location of each border was marked out either by a drag or by making a furrow. Sufficient earth to form the border was obtained by skimming the surface with scrapers. The scraper teams began next to the head ditch and worked down. They crossed and recrossed the field at right angles to the borders, and as a scraper passed a border marking it was dumped. Each scraper width of the borders was made up of two loads, but the last load overlapped the first by half the width of the scraper. The surface of each border was then leveled to within 0.1 or 0.2 foot of accuracy. The levees when first built were rough, irregular, and steep. They were cut down to a uniform grade by a homemade device called a planer, shown in figure 3.

In Imperial Valley, California, a 40-acre tract is divided in 22 lands each 60 feet wide and 0.25 mile long. When the slope is too steep the lands run diagonally across the tract. In order to lessen the first cost the material for the borders, instead of being scraped from the high portions of the lands, is taken from the sides of the borders. This creates hollows in which water may collect, makes the mowing and raking more difficult, and frequently lessens the yield. Such borders may be made by the use of the plow and ridger (fig. 4). In this method a narrow strip is first plowed and then the ridger, drawn by a number of horses, forms the loose earth into a ridge. The cost per acre for preparing the land by the border method in this valley varies all the way from $5 to $20, depending on the character of the native vegetation and the size and number of the hummocks. When creosote bushes and mesquite trees are surrounded by wind-driven sands, the cost may run as high as $40 per acre.

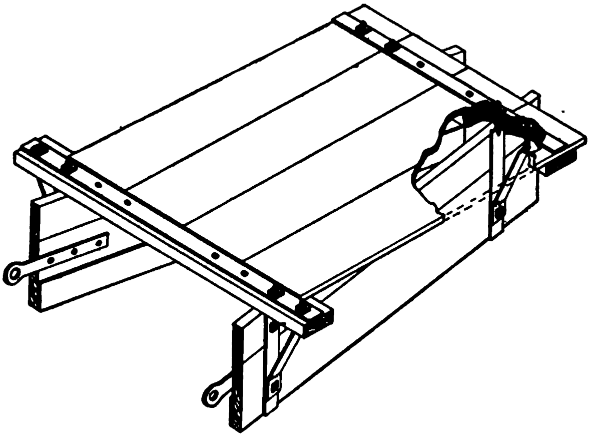
FIG. 4.—Adjustable ridger.

In Salt River Valley, Arizona, the customary method of preparing the land for alfalfa is to remove the brush, plow the high places, and roughly level the surface with suitable scrapers. Then the borders are marked off from 30 to 50 feet apart. The spacing depends on the porosity of the soil, the configuration of the land, and the head of water available. After forming rough borders by means of four plow furrows thrown together to form a ridge, a disk or spring-tooth harrow is run lengthwise of the lands. The borders are then crowded with a V crowder and usually a leveler is run transversely to the borders to round them off. The land then receives a heavy irrigation and when dry enough to work is again disked or harrowed and seeded. Such borders when first made have a base of about 3 feet and a height of 1 foot, which settles to about 9 inches. The length of the borders or lands varies from one-eighth to one-fourth mile.

The farmers on the Roswell Bench on the south side of the Boise River in Idaho make the levees 66 feet apart and 300 to 1,300 feet long, depending chiefly on the topography of the land. The land is first leveled with scrapers, then plowed and harrowed, after which the borders are marked off and thrown up by plowing two to four furrows with a heavy plow. Before seeding, a homemade planer is dragged lengthwise and crosswise of the lands in order to fill up the hollows by cutting off the high places. The cost of preparing land in this way and seeding varies from $10 to $30 per acre, depending upon the roughness of the surface.

One of the great advantages of this method is that it enables one man to use a large stream of water and irrigate a large area with a minimum of labor. The size of streams used in the Rillito Valley in Arizona varies. A head of about 100 miner's inches is turned into a plat of land 30 feet wide, and takes one to three hours to reach the lower end, 660 feet distant. Two men working twelve hours each, with this head of water, will irrigate in twenty-four hours 12 to 15 acres, at a cost of 20 to 25 cents per acre for each watering. In the extensive alfalfa fields belonging to the Butterfield Live Stock Company, of Weiser, Idaho, the head ditch has a capacity of 150 to 500 miner's inches, divided into three or four streams, and permitted to flow down as many lands until the soil is moistened to a depth of several feet. Each field receives three such waterings in a season. On the alfalfa fields in Yolo County, Cal., the natural slope of the land is about 1 foot in 400. On the shorter lands the head used is seldom less than 6 cubic feet per second, but three and four times this quantity is often applied to the longer lands. On fields well laid off, with good border gates and border levees, two men can irrigate 20 to 40 acres in twelve hours, the area within these limits depending chiefly on the size of the irrigating head. In Imperial Valley, California, the size of the head used varies from 50 to 600 miner's inches. In using a head of 500 inches it is customary to divide it among five lands. With such a head it is not unusual for two men working twelve-hour shifts to irrigate 80 acres in twenty-four hours.

THE CHECK METHOD.

The essential features of the check method of irrigation consist in surrounding nearly level plats of ground with low levees, and in making provision to flood each by means of a ditch and check box or gate. The inclosed spaces may be laid out in straight lines in both directions, thus forming with their levee borders a series of rectangles, or the levees may follow more or less closely the contour lines of the natural surface of the ground, thus forming contour checks. The most favorable conditions are a light, sandy soil on a comparatively even slope of 3 to 15 feet to the mile, abundantly supplied with water. This method is also used on heavy soils, where it is necessary to hold the water on the soil to secure its percolation to the desired depth.

In California not only does the form of the checks vary, but their size as well, some of the smaller being less than one-half acre in area, while some of the larger contain more than 10 acres.

In the Modesto and Turlock irrigation districts the surface of the land under ditch slopes about 5 feet to the mile, and is too uneven to be irrigated without being leveled first. The unevenness consists in swales, hog wallows, and mounds. The land is surveyed first either by an engineer or by the owner. In the latter case use is made of a carpenter's level, with peep sights, mounted on a tripod (fig. 5). The long side of each check should be on the flat slope and the short side on the steep slope. A fall of 3 to 5 inches between adjacent checks is preferable to either more or less. Usually the width of checks can be so adjusted as to permit of this difference in elevation. The length of each rectangle will depend on the slope in that direction as well as the location of the supply ditches. The field should be laid out in such a way that the levees may be built with the least handling of dirt. Rectangular checks possess many advantages over irregular contour checks, but if much of the better quality of surface soil has to be removed in order to build the former, the advantages may be more than outweighed by the damage caused by grading and the extra cost.

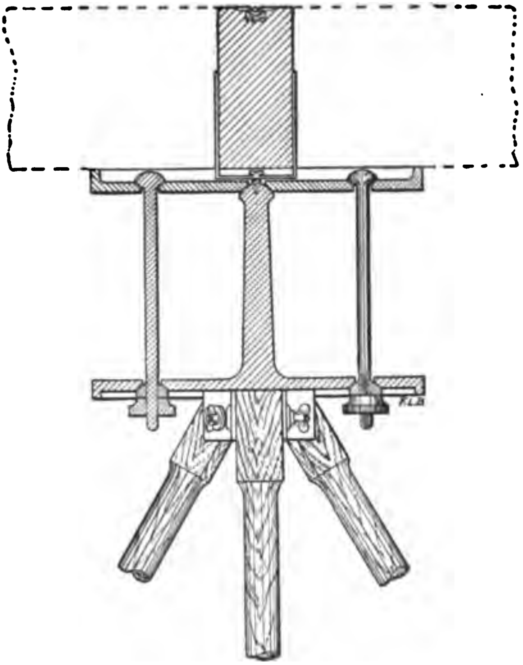

FIG. 5.—Carpenter's spirit level attached to a tripod.

Figure 6 shows in outline the rectangular checks, supply ditches, and check boxes on the farm of T. K. Beard, east of Modesto, Cal. Mr. Beard plows the land in the early spring to a depth of 6 inches with a 4-gang plow. During the summer the checks and ditches are built in a sort of rough way, no effort being made to level the floor of the checks or to smooth the levees and ditch banks. It is then heavily irrigated, and after the soil is sufficiently dry the floor of each check is carefully leveled and the levees trimmed and smoothed. For the latter purpose the grader shown in figure 7 is preferred. One passage of this grader across the top of each levee and once along each side reduces the levee to a base of 14 feet, and a height of 8 inches on the high side and 10 inches on the low side.

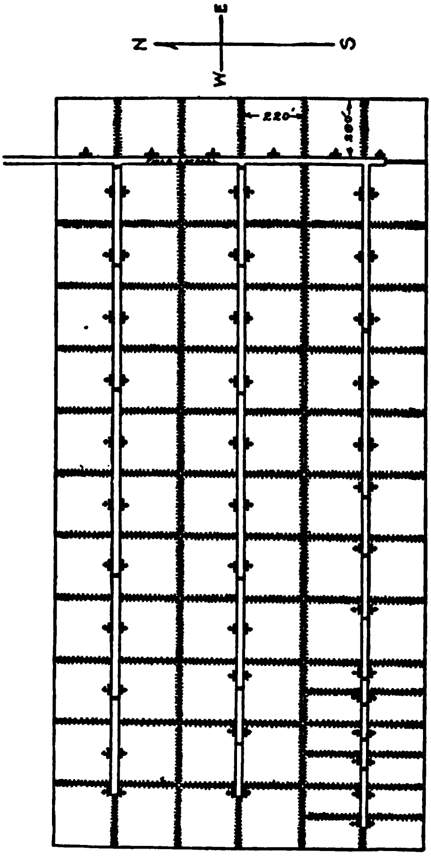

FIG. 6.—Laying out rectangular checks on farm of T. K. Beard, Modesto, Cal.

On the west side of the San Joaquin Valley the land to be seeded to alfalfa is almost invariably formed into contour checks. A common arrangement is that shown in figure 8. Here the supply ditches are intended to be about 600 feet apart, and levees are built midway between. The sides of the checks conform in a measure, but not exactly, to the natural contours, having a difference in elevation of 0.3 to 0.4 foot. The average area of a check is half an acre. In 1908 prices were obtained on the cost of preparing land in contour checks and seeding to alfalfa. The average cost on 2,067 acres of comparatively smooth grain land was $11.46 per acre. Across the river in Modesto and Turlock districts, where rectangular checking is more common and where the natural surface is more uneven, the cost was estimated at $17.50 for contour checks and $19 for rectangular checks. These latter figures included ditching, but excluded the cost of seed and seeding.

In the Modesto and Turlock irrigation districts the feed ditches are designed to carry large heads of 10 to 20 cubic feet per second.

These large heads are used by the farmers in turn for short periods of time, depending upon the acreage served. In the smaller checks a head of 5 cubic feet per second will suffice, and if 20 cubic feet per second are available four checks may be irrigated simultaneously. This head flowing on a check containing 1 acre would cover it to a depth of about 5 inches in one hour. A part of the water so applied is always lost by evaporation, but the balance percolates into the soil to furnish moisture to the plants. The skillful irrigator begins with the highest checks and works down for the reason that all waters which escape through the gopher holes or broken levees may be then applied to dry checks. To reverse this rule might result in overirrigating the lower checks. The average cost of irrigating for the season where proper check boxes are inserted is about 60 cents an acre.

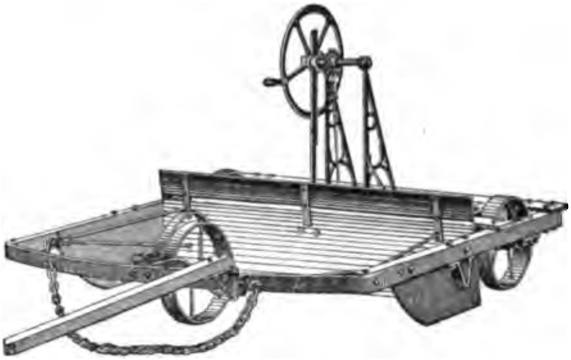

FIG. 7.—Grader.

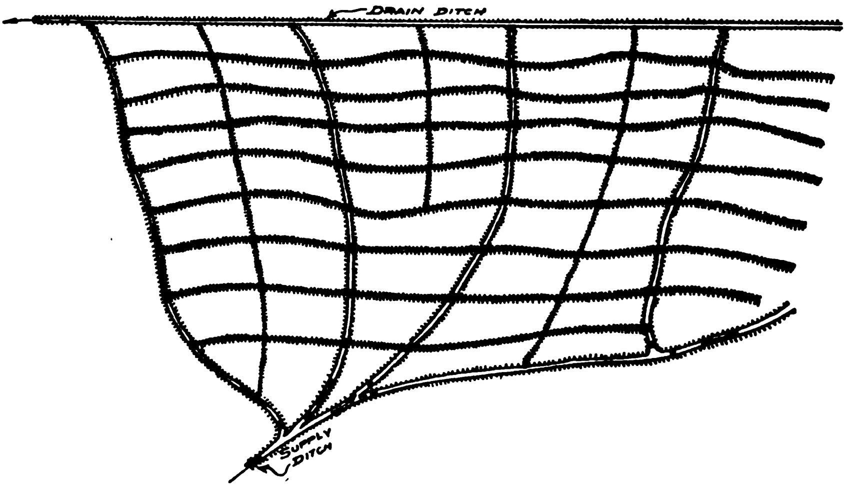

FIG. 8.—Laying out contour checks.

On the west side of the San Joaquin River each of the irregular compartments contains 1 to 3 acres, averaging about 2 acres. Few permanent wooden check boxes are used. The water is checked up by dams of coarse manure, and an opening is made in the levee bank with a shovel to admit the water. The lack of suitable boxes to control the water passing from the feed ditch into each check and the use of smaller heads greatly increase the cost of irrigating over that of the Modesto and Turlock districts. In the latter the cost for the season was estimated at 60 cents per acre, while in the former the estimate is 90 cents for each watering.

The chief advantage of the check method is that one man can attend to a large volume of water and can irrigate 7 to 15 acres in ten hours, making the cost of applying water less than by any other method except the border method. To counterbalance this important gain, there are several disadvantages which western farmers ought to consider. These are the removal of a considerable quantity of surface soil to form the levees, which frequently decreases the yield on the graded spots; the extra cost of preparing the land; the damage done to farm implements in crossing levees; and the fact that this method is not well adapted to a rotation of crops.

THE FLOODING METHOD.

Flooding from field ditches or laterals is still the most common method of applying water to the arid lands of western America. In the States of Colorado, Montana, Wyoming, Utah, and to a large extent in Idaho, alfalfa, clover, native meadows, and grain are irrigated in this way. This manner of wetting dry soil originated, it is believed, in the mountain States, and the past half century has witnessed a gradual evolution of this plan, so that now it has not only become firmly established, but is regarded as the best suited to the conditions under which it is practiced. It can be profitably used on slopes that are too steep for other methods. Fields having a firm soil and a fall of 25 feet to 100 feet have been flooded successfully. From this extreme the slope may diminish to less than 0.1 foot in 100 feet. Its cheapness is another feature which recommends it to the farmer of limited means. Ordinary raw land can be prepared for flooding at an expense of $2 to $5 per acre. Again, it is adapted to the use of small water supplies. In the mountain States the irrigation systems have been planned and built to deliver water in comparatively small streams for use in flooding or in furrows, and water users should be certain that the larger volumes required for checks and borders can be secured before going to the expense of preparing their fields for either of those systems.

In grading the land for this particular method it is not customary to make many changes in the natural surface. Only the smaller knolls are removed and deposited in the low places. An effort is made always, however, to make the farm laterals fit into the natural slope and configuration of the tract to be watered so as to bring the water to the high places. On steep slopes the laterals may be less than 50 feet apart; on flatter slopes they may be 200 feet or more apart. Whatever the spacing it is always desirable to have the slope between them as nearly uniform as possible. When the land in its natural state is uneven, the grading can be done best by a grader of the kind shown in figure 7, page 19, or a scraper of the kind shown in figure 9. When these are used, it is often advantageous to make use of some such implement as the grader shown in figure 10 for the final smoothing and grading. If the field in its natural state is comparatively smooth and level a homemade drag or leveler, as shown in figure 11, serves the purpose fairly well.

The distribution of the ditches on the field varies too widely to admit of presenting a standard plan, but figure 12 shows an arrangement of field laterals common to the mountain States. A supply ditch, AB, is built on one side and laterals, CD and EF, branch out from it on a grade of 0.5 to 0.75 inch to the rod. These laterals are spaced 75 to 100 feet apart and are made with double moldboard plows, either walking or sulky. Figures 13 and 14 illustrate other common arrangements in use in northern Colorado.

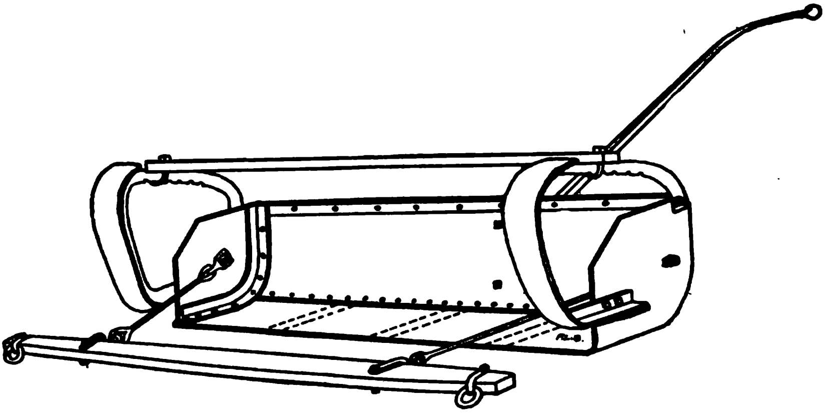

FIG. 9.—Scraper.

In the vicinity of Fort Collins, Colo., the main lateral is built to the highest corner of the field to be irrigated and the smaller laterals extend out from it, spaced 75 to 225 feet apart, the spacing depending on the slope of the ground and the coarseness of the soil. The size of the laterals is governed by the head which may be had, but on steep slopes and on soil that erodes readily, small heads are best. Around Berthoud, Colo., the land is naturally of uniform, even slope, and little grading has been necessary. Heavy timber or iron drags are used to smooth the surface after plowing so that the water will spread evenly. These are built in various ways and out of whatever material happens to be available on the farm. Worn-out steel rails, such as have been removed from a railway, are often used, two rails being fastened together about 30 inches apart. A team is hitched to each end and the driver rides on the drag. Once over a field with a drag of this kind is usually sufficient to make the surface quite uniform and smooth. The proper location for field laterals is usually evident to the irrigator without the use of surveying instruments, though in fields where the fall is slight it is often necessary to have a topographical survey made and the laterals located by an engineer. Field laterals are always so located that they cover the highest parts

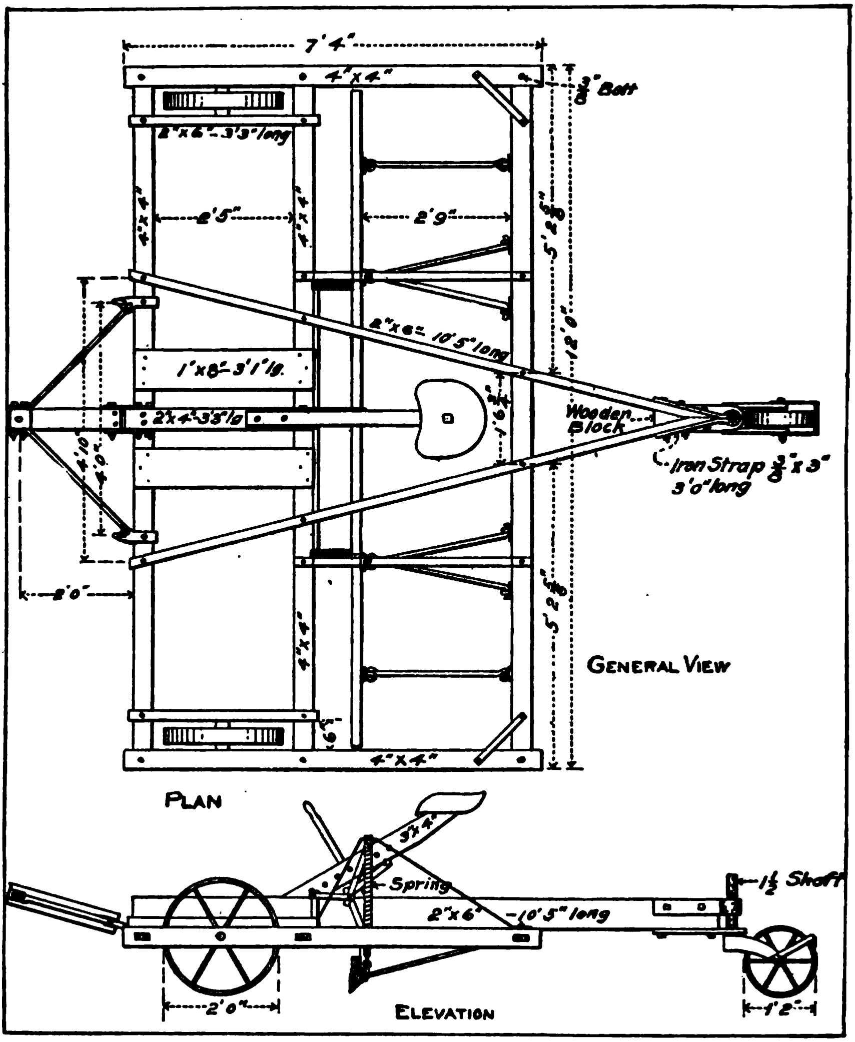

FIG. 10.—Leveler used in Gallatin Valley, Montana.

of the field and their distance apart in alfalfa varies from 10 to 20 rods.

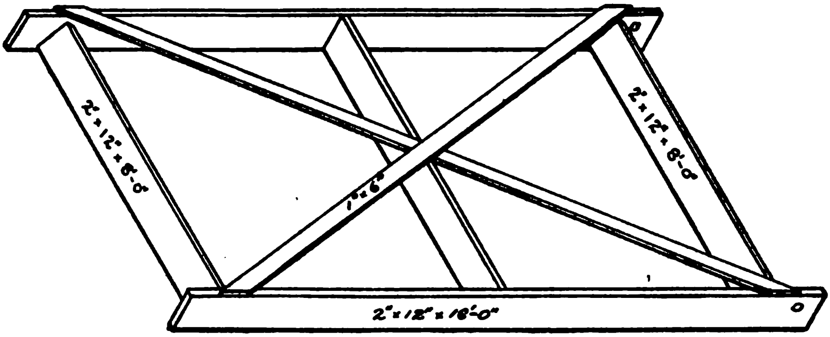

FIG. 11.—Homemade drag or leveler.

The head required for flooding from field laterals in northern Colorado varies from 2 to 3 cubic feet per second and is divided between two or three laterals. Canvas or coarse manure dams are used to check the water in the laterals and to force it out over the banks and down the slopes of the fields. In less than three hours the upper foot of soil is usually thoroughly moistened. To apply one watering in this way costs from 15 to 30 cents an acre.

In flooding clover and alfalfa fields in Montana the field ditches usually run across the field on a grade of 0.5 to 0.75 inch to the rod. (See fig. 12.) The spacing between ditches varies with the slopes, the smoothness of the surface, and the volume of water, but 80 feet is about an average. The head used is seldom less than 1.5 or

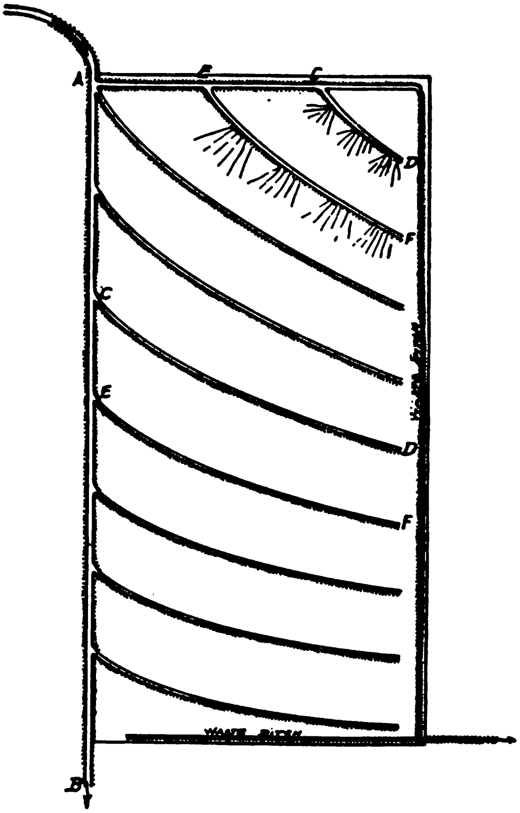

FIG. 12.—Preparing land for flooding in Montana.

more than 4 cubic feet per second, the larger heads being divided between two or three ditches. In irrigating, a canvas dam is first inserted in each ditch or set of ditches, 75 to 100 feet below the head. The water is then turned into each channel and flows as far as the canvas dam, by which it is checked and as a consequence rises and flows over the low places of the lower bank or through openings made with the shovel. When these small tracts have been watered, the canvas dam is raised, dragged down the lateral 75 to 100 feet, and again inserted in the channel to serve the next tract. Manure dams sometimes take the place of the movable canvas dams. Some time before a field is to be irrigated and after the ditching is done coarse manure is placed in small heaps within each ditch channel at suitable intervals and each heap is covered with earth on its upper face to a depth of 1 to 2 inches. When this check has served its purpose it is broken and the water flows down until stopped by the next check. In some instances permanent wooden check boxes are inserted in each lateral, while in others the canvas dam is used. The thorough irrigation of 4 acres is considered a good twelve hours' work for one man. By the use of 100 miner's inches, two men can irrigate 7 to 10 acres in twenty-four hours at a cost of 45 to 65 cents per acre.

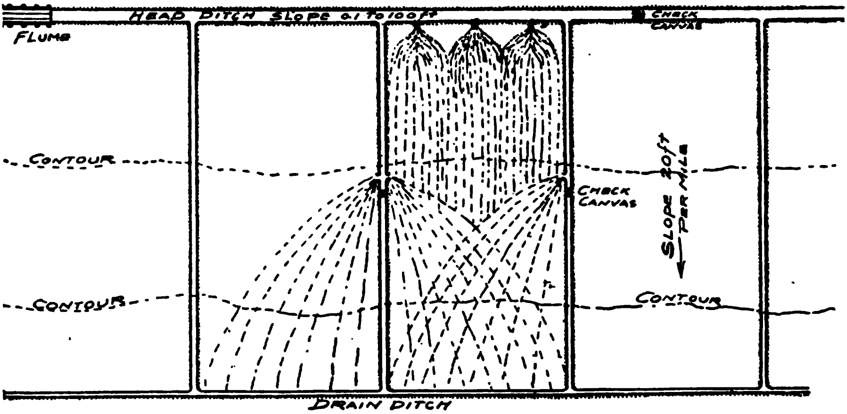

FIG. 13.—Flooding from head ditches in northern Colorado.

In the Salt Lake Basin the heads of water used by the irrigators of alfalfa vary considerably with the flow of the streams. In spring heads of 4 to 6 cubic feet per second are common, while later in the season when the streams are low they are reduced to 1 to 3 cubic feet per second. A field is usually divided into strips 200 to 500 feet wide by laterals extending across it (fig. 12). A permanent wooden check box or a canvas dam is inserted in the main supply ditch below each cross ditch, causing the water to flow into the cross ditch. From there it is spread over the surface through small openings in the ditch bank and any excess water is caught up by the next lower ditch. In this way each ditch serves a double purpose, acting as a drainage channel for the land above it and as a supply channel for the land below it.

In summarizing the advantages of the flooding method, it may be said that in first cost it is one of the cheapest, it is adapted to the delivery of small volumes of water (50 to 100 miner's inches) in continuous streams, it is particularly well adapted to forage and cereal crops of all kinds, the top soil is not removed from the high places to fill up the low places, and firm soil, although it be on steep and irregular hillsides, can be successfully watered.

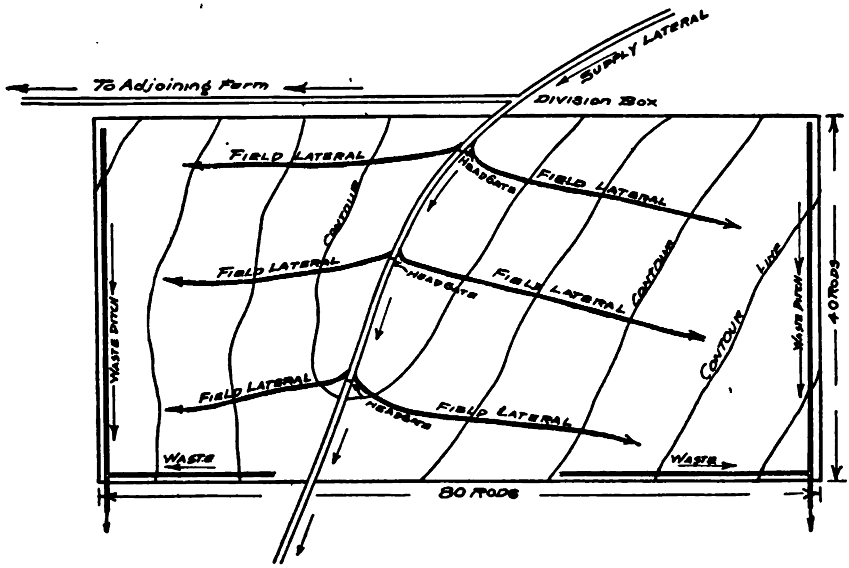

FIG. 14.—A 20-acre alfalfa field near Berthoud, Colo., showing supply lateral, field laterals, contours, and waste ditches.

The chief disadvantages consist in the fatiguing labor required to handle the water, the small area which one man can irrigate in a day, the difficulty in applying water after dark, and the unequal distribution of water on the field unless more than the average care is exercised.

THE FURROW METHOD.

Alfalfa, native meadows, and grain are most commonly irrigated by one of the methods previously described rather than by the furrow method, which is the usual method of irrigating orchards, gardens, root crops, and vegetables. The irrigating of alfalfa from furrows is at present confined to the Yakima Valley, Washington, to portions of the Snake River Valley in southern Idaho, and to comparatively small areas in other States. In the localities named the soil is a fine clay loam which runs together, puddles when wet, and bakes and cracks when dry. Flooding the surface by any of the customary methods tends to puddle the top layer of soil, which becomes quite hard when the moisture is evaporated. The puddling and baking processes injure alfalfa, and it was with the object of keeping as much as possible of the surface dry that furrows were introduced. When a small stream is permitted to run in the bottom of a furrow for several hours the soil beneath and for some distance on each side becomes wet, while the surface may remain nearly dry. This is shown in figure 15, which gives the area wetted from a furrow 5 inches deep in seven hours as determined in one of the orange orchards of southern California.

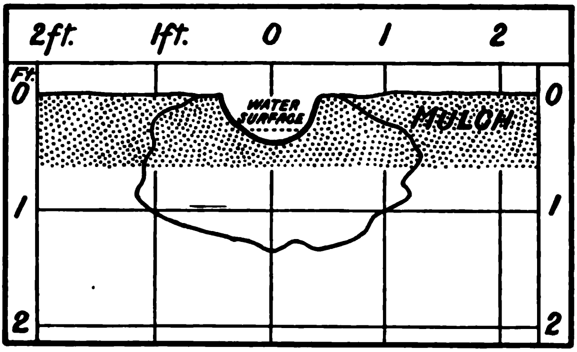

FIG. 15.—Outlines of percolation from furrow 5 inches deep, in seven hours.

The alfalfa grown in the Yakima Valley in Washington is practically all irrigated by means of furrows. The grading is usually done by buck scrapers (fig. 16), while a long, rectangular drag similar to the one shown in figure 11 (p. 23) removes most of the surface inequalities that remain after the surface has been leveled roughly by the scraper. The float is made of two 2 by 6 inch timbers about 20 feet long, held in position by crosspieces of the same size 6 feet long.

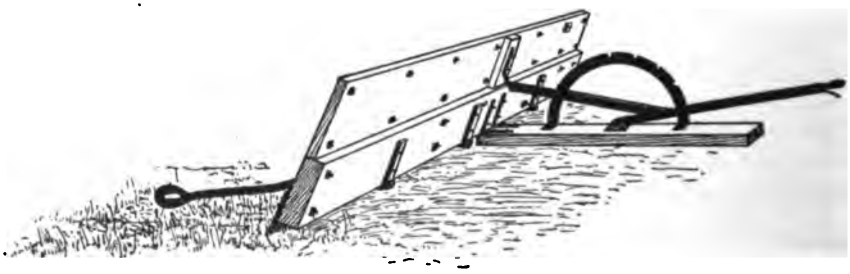

FIG. 16.—Buck scraper.

The common practice is to run the furrows across the entire width or length of a field, and in consequence their length varies from 20 rods or less in small fields to 80 rods in large fields. As a rule, the furrows are too long. Farmers object to cutting up a field by head ditches, but in a climate like that of the Yakima Valley in midsummer by far the most essential element in plant production is water, and all other considerations should give place to it. It has been shown[a] that water is rarely distributed evenly in furrow irrigation and that much is lost by deep percolation. To increase the length of a furrow beyond 660 feet, or one-eighth mile, not only increases the loss but renders a uniform distribution more difficult to secure. Except in rare cases, this distance should be regarded as the limit for the length of furrows. In light, sandy soils, having a porous gravel stratum beneath, the length may well be reduced to 250 feet.

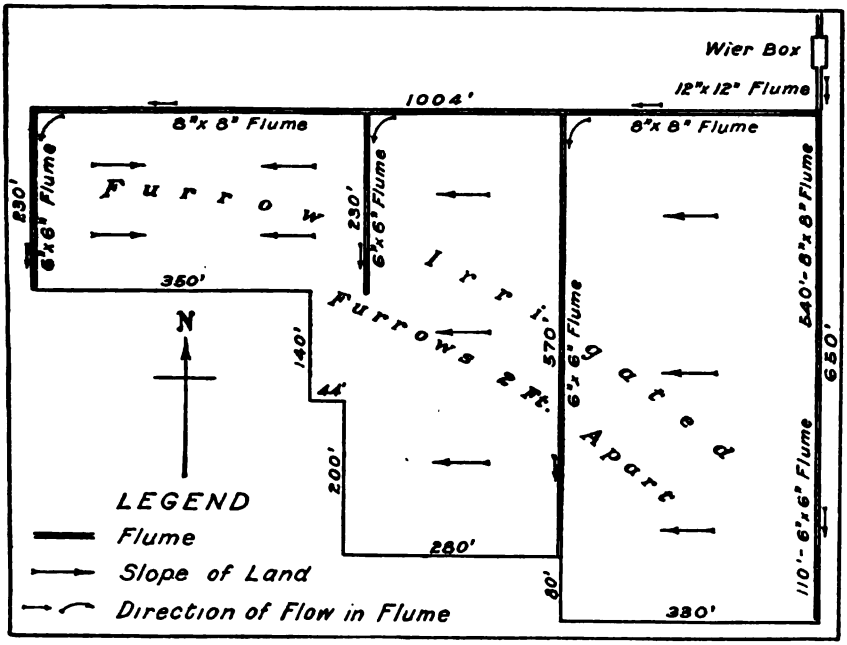

FIG. 17.—Showing tract prepared for furrow irrigation.

Figure 17 shows the manner of dividing an alfalfa field for furrow irrigation at Kennewick, Wash. Lumber head flumes, either 8 by 8 inches or 6 by 6 inches, are placed along the upper boundary of each strip and the direction of the flow in both flumes and furrows is indicated by arrows. Auger holes are bored through one side of the flume flush with the bottom at points where water is to be delivered to the heads of furrows. A short piece of lath revolving on a nail controls the flow from each opening. On steep grades a cleat on the bottom of the inside of the flume nailed on crosswise just below each opening will dam back the water and increase the discharge.

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[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 203.

When flumes are considered too costly the water is distributed among the furrows through wooden spouts set in the bank of an ordinary earthen ditch (fig. 18). These head ditches when in operation are divided into a series of level spaces by means of drop boxes which hold the surface of the water at the desired elevation. The spacing of these drop boxes depends on the grade of the head ditch and their cost averages about $2.50 each. Spouts are made usually by nailing together four lath. There is a special lath on the market somewhat heavier than the ordinary one used for plastering buildings, being 0.5 inch thick, 2 inches wide, and 3 feet long. Four of these when nailed together cost about 3.5 cents and each spout in place costs about 6.5 cents. Assuming that they are spaced 4 feet apart the spouts for a square tract of 10 acres would cost $10.73, or slightly more than $1 per acre. The cost of an ordinary head ditch, with four drops or check boxes, would be about $15 for the same tract, or $2.50 per acre for both, exclusive of grading, smoothing, and leveling. Tin tubes, 0.5 inch in diameter, one to each furrow, have sometimes been used instead of the wooden tubes. When set 0.5 inch below the water surface each tube discharges about 0.1 miner's inch, which is about right for a slope of 3 per cent. The length of the tin tubes is governed by the size of the ditch bank. The tubes are set while the water is in the ditch and are kept at the same level between check boxes. The cost of tin tubes 2 feet long is about $3 per hundred. In many places neither flumes nor tubes are used. Water is taken through cuts in the ditch bank and divided among the furrows as evenly as possible by directing it with the shovel. This practice reduces the cost of preparing the land for irrigation, but it increases the cost of applying water, and does not secure an even distribution among the furrows.

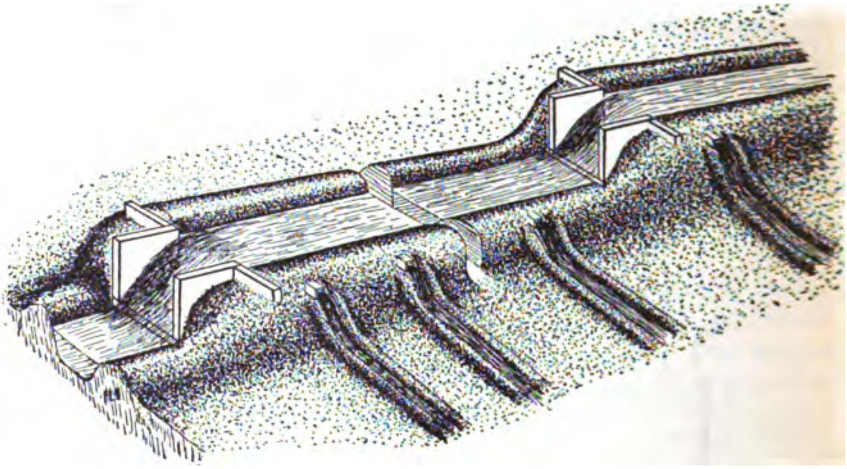

FIG. 18.—Manner of placing tubes in ditch bank for furrow irrigation.

Furrows in alfalfa fields are most commonly made by the use of a marker, or furrowing sled (fig. 19). Sleds with more than two runners are sometimes used, reducing the time required for furrowing, but not producing quite so satisfactory furrows, since an obstruction under one of the outside runners will lift all but the other outside runner out of the ground and leave obstructions in the furrows, which, if not removed, will cause the flooding of the surface. Sometimes a marker is put on the sled to indicate the place for the next furrow.

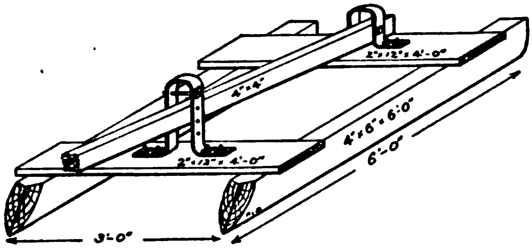

FIG. 19.—Furrower used on experiment farm, Riverton, Wyo.

For the irrigation of most of the crops grown in the vicinity of Twin Falls, Idaho, the feed ditches are laid out across the field as nearly parallel as possible on a grade of 2 to 6 inches to 100 feet and 300 to 500 feet apart. Furrows are made in the direction of the greatest slope and approximately at right angles to the feed ditches. Starting at the upper end, a wooden check is inserted in the ditch at the end of each fall of 12 inches. Thus, if the ditch has a fall of 4 inches to 100 feet the checks are placed 300 feet apart. Each check box is provided with a removable flashboard, which, when in place, backs the water to the next check above and at the same time permits the surplus water to flow over its top to supply the checks below (fig. 20). Lath tubes 16 to 24 inches long are inserted in the lower ditch bank about 3 inches below the water level formed by the flashboards when in place. These tubes are put in while the check is full of water in order that all of each set may be on the same level and that water may be had for puddling. The flow from each tube may be divided among several furrows. Ordinarily a

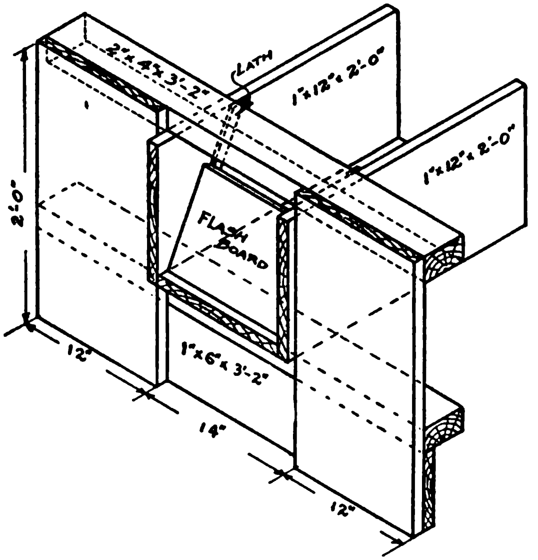

FIG. 20.—Check box for furrow irrigation.

40-acre farm will require about 30 check boxes and 1,800 tubes. Nearly one-half the tubes ought to be 24 inches long to insert near the check boxes where the bank is heaviest, while the remainder may be 16 inches long. The check box shown in the sketch (fig. 20) calls for 17 b. m. feet of lumber, but a serviceable box can be made out of old packing boxes.

Some of the advantages of this method over ordinary furrow irrigation are: A constant head over the inlets of each set of tubes while the surplus passes down the field ditch; the opportunity to use one or all or any combination of checks at the same time, as it is possible to regulate the head and consequently the discharge by raising or lowering the flashboard; and the automatic character of the water distribution while irrigating.

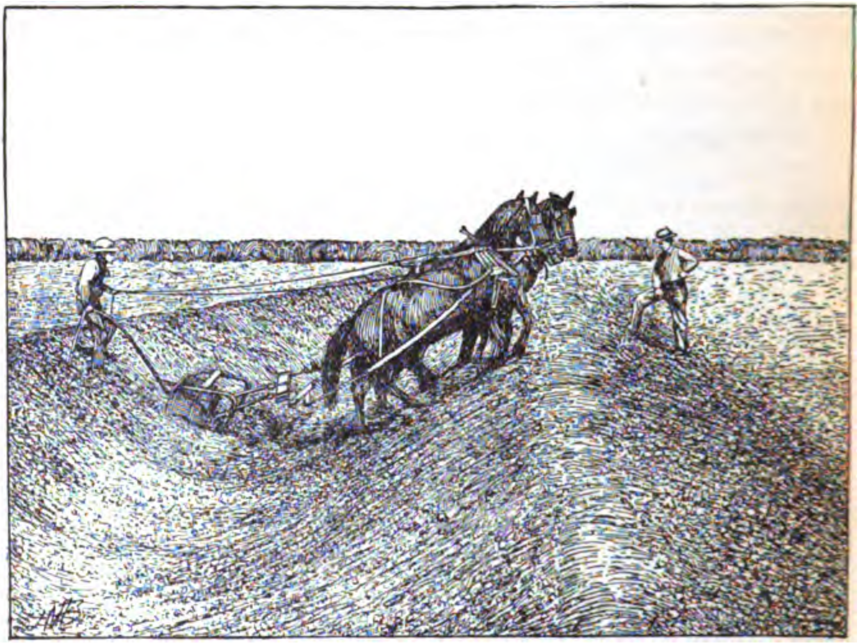

FIG. 21.—Building a supply ditch.

No fixed rule can be given as to the proper spacing of the furrows or the time water should run in each. In heavy retentive soils the furrows may be 2 to 2.5 inches deep and only 16 inches apart, while in more open soils the furrows may be 48 inches apart.

The amount of water which should flow in each furrow depends on the character of the soil and the slope. It is a common practice in the Yakima Valley to space the furrows 18 to 24 inches apart when the seeding is done, but as the plants grow their roots soon penetrate several feet into the soil and alternate furrows are then abandoned. If the tract contains 10, 20, or 30 acres the furrows run all the way across, if the slope will allow it. Water is frequently run a quarter of a mile in the small furrows. In furrows 660 to 1,320 feet long in sandy loam, the water has to be kept running continuously for about two days, and consequently there is usually much waste due to deep percolation. In distributing water in furrows it is a good plan to follow the practice of the irrigators of the orange belt in southern California, who turn into each furrow, until the furrows are wet, three or four times as much water as will be permitted to remain, and then reduce the flow.

FARM DITCHES.

The capacity and, to some extent, the location of farm ditches depend chiefly on the method of applying water. In the border method the supply ditch is usually large and so located as to convey a sufficient volume of water to the head of each land. In Imperial Valley in California these head ditches, as they are called, have a bottom width of 6 feet and a surface width of 12 to 14 feet. In building a ditch of this size a strip 6 feet wide on the center line of the ditch is plowed 6 inches deep. Then parallel strips, also 6 feet wide, are plowed 8 feet distant from it. Scraper teams then cross and recross these, taking dirt from the plowed strips and dumping it on the unplowed spaces to form the banks (fig. 21). The banks when completed are about 2 feet above the natural surface of the ground, and the bottom of the ditch is 6 to 10 inches below it. When it is deemed best not to create a depression at the outer toe of each embankment, the borrowed dirt is taken from the high parts of the adjacent land.

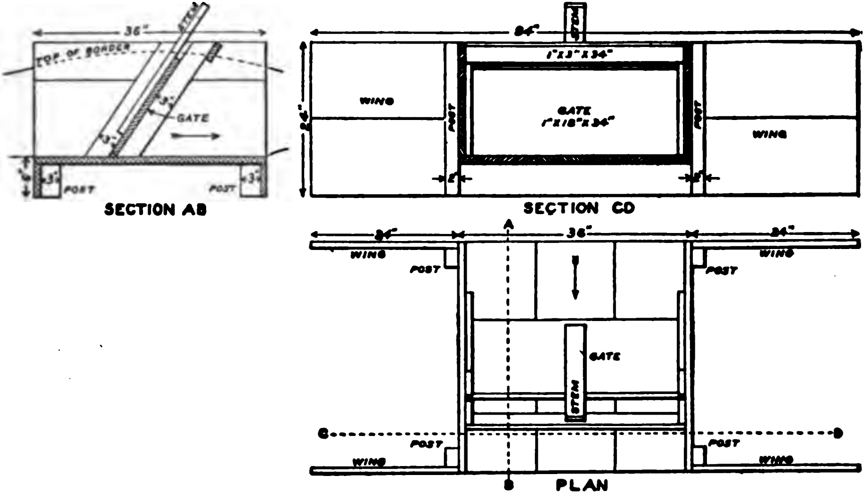

FIG. 22.—A border gate used in Imperial Valley.

The water required for each land is withdrawn from the head ditch through a border gate. These are usually made of wood. Figure 22 shows the type of border gate used by F. N. Chaplin, of

Holtville, in Imperial Valley. It requires 49 feet b. m. of redwood which, at $42 per thousand, makes the lumber cost $2.06. The hardware, carpentry, and setting increase the cost to about $3.25.

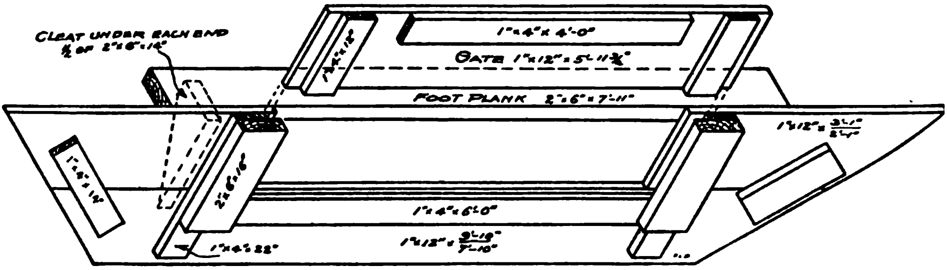
CLEAT UNDER EACH END ½ OF 2"×6"×14"
1"×4"×4'-0"
GATE 1"×12"×5'-11¾"
FOOT PLANK 2"×6"×7'-11"
1"×12"×$\frac{3'-1"}{2'-4"}$
1"×8"×12"
2"×6"×16"
1"×4"×6'-0"
1"×4"×22"
1"×12"×$\frac{9'-10"}{7'-10"}$

FIG. 23.—Border gate used near Sunset City, Cal.

If it is assumed that 22 gates are needed for a 40-acre tract the cost per acre for the border gates is $1.79. A cheaper border gate is shown in figure 23, which represents the kind used on an alfalfa tract at Sunset City, Cal. In some localities concrete is being substituted for wood and figure 24 shows a border gate of this material, quite generally used for the irrigation of alfalfa in Yolo County, Cal.

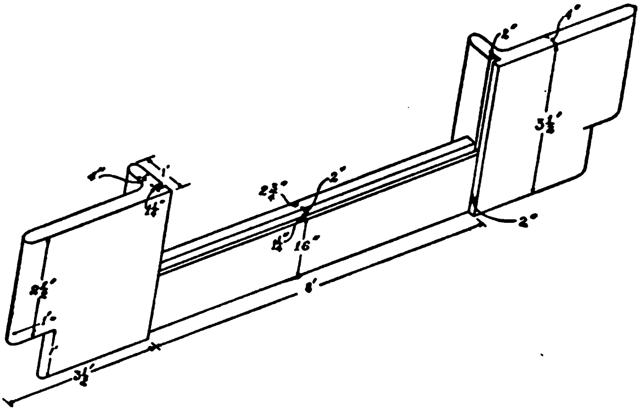

FIG. 24.—Concrete gate used in Yolo County, Cal.

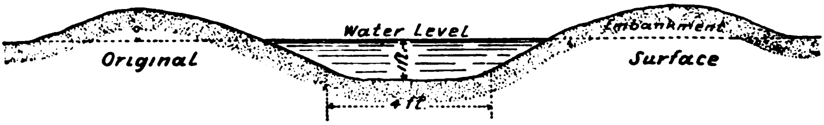

FIG. 25.—Supply ditch with bottom width of 4 feet.

In the check method of irrigation the volumes used do not differ materially from those required to flood the lands in the border method, and the feed ditch for the checks corresponds in size and capacity to that of the head ditch for borders. Cross sections of common forms of supply ditches are shown in figures 25 and 26. The carrying capacities of these ditches under different grades are given in the accompanying table:

Mean velocity and discharge of ditches with different grades.

SUPPLY DITCH, FIGURE 25.

Grade.			Mean velocity in feet per second.	Discharge.	
Inches per rod.	Feet per 100 feet.	Feet per mile.		Cubic feet per second.	Miner's inches under 6-inch pressure head.
1/16	0.03	1.58	0.84	4.20	168
[illegible]	.06	3.33	1.08	5.40	216
[illegible]	.13	6.67	1.54	7.70	308
[illegible]	.19	10.00	1.89	9.50	378
[illegible]	.25	13.33	2.20	11.00	440
[illegible]	.31	16.67	2.45	12.20	490
[illegible]	.38	20.00	2.69	13.40	538

SUPPLY DITCH, FIGURE 26.

1/16	0.03	1.67	1.03	11.60	464
[illegible]	.06	3.33	1.48	16.70	666
[illegible]	.09	5.00	1.82	20.50	819
[illegible]	.13	6.67	2.11	23.70	950
[illegible]	.16	8.33	2.35	26.40	1,058
[illegible]	.19	10.00	2.58	28.00	1,121
[illegible]	.22	11.67	2.80	30.50	1,260

In flooding land from field laterals two kinds of channels are needed. The larger ones convey the water to the highest corners of the fields and along one or two borders of each field; the smaller distribute the water over the field. In this method of applying water smaller streams are used than in either the check or border method. Except on large farms the stream seldom exceeds 3 cubic feet per

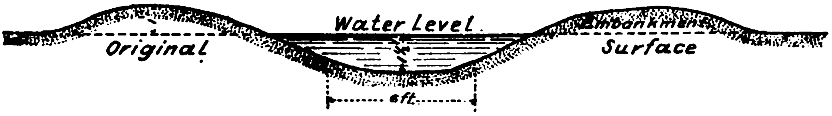

FIG. 26.—Supply ditch with bottom width of 6 feet.

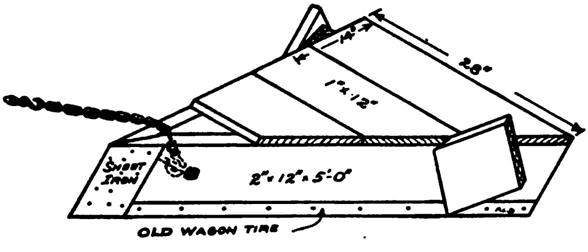

FIG. 27.—"A" crowder.

second, and is usually between 2 and 3 cubic feet. On ordinary grades only a small channel is needed for this volume. Such channels are made by plowing first a strip as wide as the surface of the ditch is to be when full and removing the loose dirt by one of several designs of A crowders, two of which are shown in figures 27 and 28. One of the best implements for making field laterals is a 14 or 16 inch lister plow on a sulky frame. Figures 29 and 30 show cross sections of lateral ditches made in this way, while figure 31 represents a common type of supply ditch. The effect which grade has upon such channels is shown in the accompanying table, giving discharges of these ditches, with various grades.

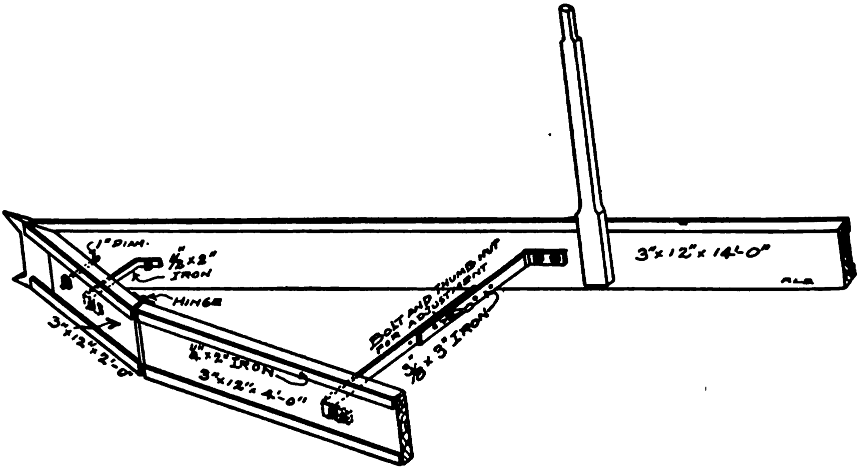

FIG. 28.—Adjustable "A" scraper or crowder.

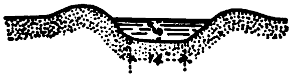

FIG. 29.—Lateral ditch with bottom width of 14 inches.

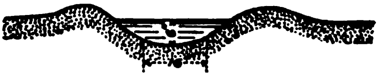

FIG. 30.—Lateral ditch with bottom width of 16 inches.

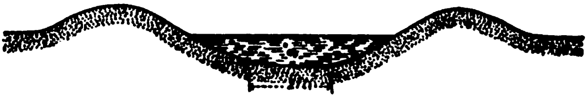

FIG. 31.—Lateral ditch with bottom width of 2 feet.

Table giving the mean velocity and discharge of ditches with different grades.

LATERAL DITCH, FIGURE 29.

Grade.			Mean velocity in feet per second.	Discharge.	
Inches per rod.	Feet per 100 feet.	Feet per mile.		Cubic feet per second.	Miner's inches under 6-inch pressure head.
½	0.25	13.33	1.01	0.67	27
¾	.38	20.00	1.23	.81	32
1	.51	26.67	1.42	.93	37
1¼	.63	33.33	1.59	1.05	42
1½	.76	40.00	1.75	1.16	46
2	1.01	53.33	2.04	1.35	54
2½	1.26	66.67	2.28	1.50	60
3	1.51	80.00	2.50	1.64	61
3½	1.77	93.33	2.70	1.78	71

LATERAL DITCH, FIGURE 30.

¼	0.13	6.67	0.82	0.80	30
½	.25	13.33	1.16	1.00	42
¾	.38	20.00	1.42	1.30	52
1	.51	26.67	1.64	1.50	60
1¼	.63	33.33	1.84	1.70	67
1½	.76	40.00	2.02	1.80	74
1¾	.88	46.67	2.18	2.00	80
2	1.01	53.33	2.34	2.10	86
2½	1.26	66.67	2.61	2.40	96

LATERAL DITCH, FIGURE 31.

⅛	0.06	3.33	0.79	2.08	83
¼	.13	6.67	1.13	3.00	119
½	.25	13.33	1.60	4.20	168
¾	.38	20.00	1.97	5.20	207
1	.51	26.67	2.28	6.00	239
1¼	.63	33.33	2.57	6.80	270

THE SUBIRRIGATION OF ALFALFA FIELDS.

As a general thing, alfalfa is irrigated from the surface downward by one of the methods previously described. There is, however, a small percentage of alfalfa lands, probably not more than 5 per cent of the total, which is irrigated from below. Frequently the seepage water from porous, earthen ditches and the waste water from irrigated areas pass through the subsoil of lower fields sufficiently near the surface to subirrigate them. In other places these seepage waters collect at the lower levels and raise the ground water near enough the surface to supply the plants with the needed moisture. It is questionable if alfalfa growers should place much dependence on this mode of supplying moisture to the plant. What is gained in not having to irrigate is usually more than lost in damage done to both soil and crop by the rise of the ground water. Wherever alkali is prevalent the rise of the ground water near the surface is almost certain to be followed by an accumulation of alkali on the surface.

Again, the fact that alfalfa fields subirrigate is usually nature's way of giving warning that the ground water is rising dangerously near the surface, and observations should be made to determine if the level is above the danger limit. One of the best ways of making such determinations is by means of bored test wells. These are made by boring holes (fig. 1, p. 9) from 2 to 4 inches in diameter in different parts of the field and noting at regular intervals the elevation of the ground water in each. Where the subsoil is a clay or a clay loam no lining will be necessary other than a joint of drain tile or a short wooden tube. Where the subsoil is loose it may be necessary to line the wells with thin galvanized iron or with a wooden box. The wells may be connected by a line of levels, the elevations being taken on the tops of stakes driven beside the wells. These well records, if taken at weekly or even monthly intervals, for several years, will show at a glance not only the position of the ground water, but also its rise and fall throughout the seasons. Whenever it is found that the water table stands for any considerable time at less than 4 feet from the surface there is cause for alarm, and measures should be taken to prevent such an accumulation of seepage waters or to remove the surplus by drainage.

Alfalfa is subirrigated also from the beds of streams. On bottoms the danger is not so great, because there is less alkali present and the height of the ground water is governed by the condition of the stream. It happens often that when the water table is at its highest point the alfalfa plants are dormant or nearly so, and as a result are not so readily injured. Two cases of successful subirrigation from stream channels are here cited by way of illustration.

On the farm of J. A. King, located on the second bottoms about 5 miles northeast of Boulder, Colo., the water table is 10 to 12 feet below the surface. An average yield of alfalfa of 4 tons per acre has been obtained for the past nine consecutive seasons from this farm without any perceptible deterioration. The crop was irrigated the first year, but after that the roots had evidently reached water and continued to draw their supply from that source.

On the Arkansas River south of Cimarron, Kans., John Bull has an alfalfa field of over 50 acres which is subirrigated. The water table is found at a depth of 6 to 8 feet, and the yield is usually 1 ton at each cutting. It is cut three to five times each season, and in some years one crop of seed and two crops of hay are raised.

Throughout the arid region there are a few localities where subirrigation is quite generally practiced. Perhaps the most notable of these is to be found in the vicinity of the towns of St. Anthony and Sugar City, in the upper Snake River Valley in Idaho. This subirrigated district comprises an area of about 60,000 acres. A characteristic of the subsoil of this large area is that it is composed of sand

and gravel, sometimes mixed with cobble rock to the lava bed rock, which is found at depths varying from a few feet to 90 feet. The surface soil around St. Anthony is a dark-colored gravelly loam 2 to 4 feet deep. On the Egin Bench it is a dark sandy loam 1.5 to 5 feet deep, while around Sugar City it is a clay loam 4 to 6 feet deep. The land slopes to the south and west at the rate of about 10 feet to the mile.

At first ordinary ditches were built and for years attempts were made to irrigate the land by the usual methods. These failed, however, since all the water turned into the ditches soon sank into the porous subsoil beneath. In time much of this subsoil filled up with water, due to an impervious lava bed rock, and the top layers of soil became moistened from below. This condition led the farmers to adopt a new method of irrigation, a type of which is shown in figure 32. On a farm of 120 acres, the property of C. H. DeCamp, located 12 miles south of St. Anthony, Idaho, the main canal passes along the north and west boundaries. From this a supply ditch is run which feeds the smaller laterals. These laterals are shallow ditches

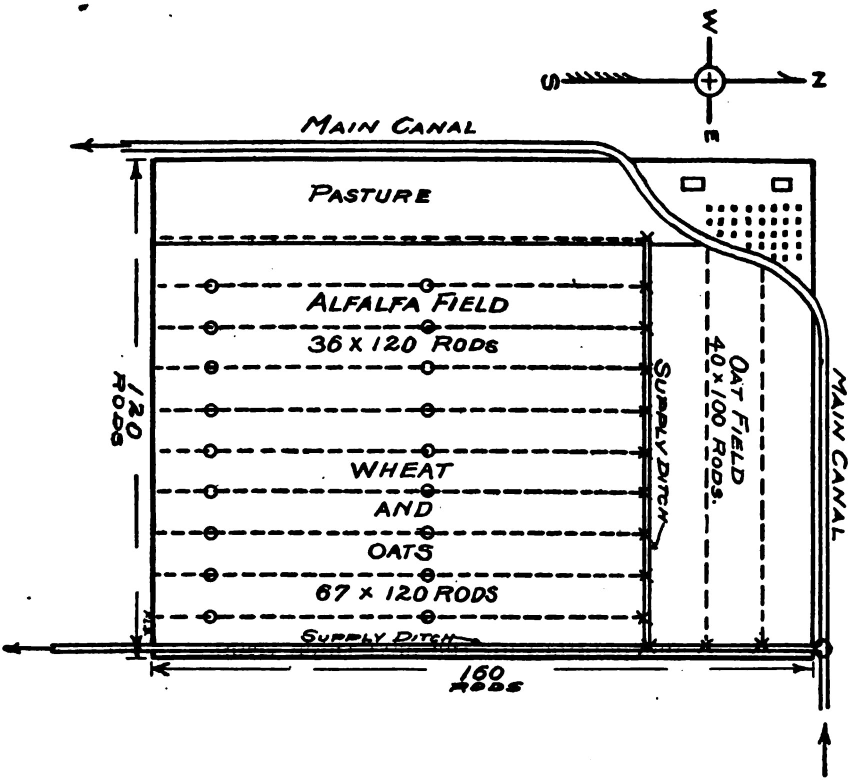

FIG. 32.—One hundred and twenty-acre subirrigated farm of C. H. DeCamp, 12 miles south of St. Anthony, Idaho.

about 3 feet wide and 6 inches deep and divide the farm into strips. On the majority of farms the laterals do not exceed 1,320 feet in length and are spaced 100 to 300 feet apart. On this particular farm their length is increased beyond the average and their width decreased. In this mode of irrigation no water is spread over the surface; the laterals merely distribute 15 to 20 miner's inches each to different parts of the field, where it soon joins the ground water by sinking through the bottoms of the shallow ditches. The land is planted in the early spring when the ground water is low, and then water is turned into the ditches and kept in day and night until the ground water rises sufficiently near the surface to supply the needed moisture to the roots of plants. Thereafter the height of the ground water is regulated by the amount of water turned into the supply ditch. The rise and fall of the ground water is determined by means of small boxes set in the ground 3 to 5 feet deep, as indicated by the circles in figure 32. Twenty to 30 boxes are usually required for each 80-acre farm. All water is turned out of the main canal prior to September 15 to permit the land to dry out for the harvesting of such crops as sugar beets, potatoes, etc. When the crops are removed, a small stream is left running in the main canal all winter; but notwithstanding this supply, the ground water usually falls from 6 to 20 feet below the surface during the fall and winter months. This somewhat novel method of applying water has led to the adoption of a rotation of crops which seems to suit both water and soil conditions. Alfalfa does not do well after the third year. This is chiefly due to the height at which the ground water is kept during the spring and summer months. Then, too, the soil is lacking in humus. These conditions have led the farmers to grow alfalfa on a tract for two or three years and then to turn the alfalfa under and raise grain, sugar beets, and potatoes for the next three years. Under this rotation the yields per acre on well-managed farms are 40 to 60 bushels of wheat, 75 to 110 bushels of oats, 50 to 90 bushels of barley, 300 to 500 bushels of potatoes, 15 to 20 tons of beets, and 4 to 6 tons of alfalfa. The land sells for $100 to $150 an acre.

AMOUNT OF WATER REQUIRED.

Alfalfa requires more water than most crops. This is readily accounted for by the character of the plant, the rapidity with which it grows, the number of crops produced in one season, and the heavy tonnage obtained.

As a result of careless practice there is a lack of uniformity in the quantity of water used, the volumes applied frequently being far in excess of the needs of the crop. The majority of the records collected and published by this Office show a yearly duty of water for alfalfa ranging from 2.5 to 4.5 feet in depth over the surface, while in quite a large number of cases the volumes applied would have covered the area irrigated to depths of 6 to 15 feet.

From the large number of measurements made on the duty of water it is possible to select some that possess great value, since they indicate what can be accomplished with a given quantity of water.

During the season of 1904 careful measurements were made by C. E. Tait, of this Office, of the amount of water used on alfalfa fields in the vicinity of Pomona, Cal. The rainfall at Pomona for the winter of 1903–4 was much below the normal and amounted to about 9.1 inches.[a] The quantity of irrigation water applied by pumping averaged 2.3 feet in depth and the yield of cured hay averaged from 1 to 1.5 tons per acre per crop, five or six crops being common. These figures are corroborated by many others collected in southern California. Perhaps in no other locality of the arid region is a greater tonnage of alfalfa obtained, yet in a climate of scanty rainfall having a long, dry, hot summer only a comparatively small amount of water is used. About a third of the 9,000 acres irrigated by the Riverside Water Company is in alfalfa and for the past seven years the average depth applied has been 2.31 feet, while the depth of rainfall and irrigation water combined has averaged 3.18 feet.

In 1903 the writer, when director of the Montana Experiment Station, applied different depths of water to seven plats of alfalfa with the results given in the following table. It will be seen that a high tonnage for so short a season as prevails in Montana was obtained from plat 5 with the use of 2 feet of water. By irrigating plat 6 seven times, and plat 7 eight times, it was possible to increase the yield to the amounts stated. The results of this experiment seem to confirm the best practice of southern California, which may be summed up by stating that in localities having an annual rainfall of about 12 inches remarkably heavy yields of alfalfa may be obtained from the use of 24 to 30 inches of irrigation water, providing it is properly applied.

Quantities of water applied to alfalfa and yields secured, Montana Experiment Station.

Plat number.	Depth of irrigation.	Depth of rainfall.	Total depth.	Yield per acre of cured alfalfa.
	Feet.	*Feet.*	*Feet.*	*Tons.*
1	0.5	0.70	1.20	4.61
2	None.	.70	.70	1.95
3	1.0	.70	1.70	4.42
4	1.5	.70	2.20	3.75
5	2.0	.70	2.70	6.35
6	2.5	.70	3.20	7.20
7	3.0	.70	3.70	7.68

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[a] U. S. Dept. Agr., Weather Bureau, Climate and Crop Service, California, Ann. Sums., 1903 and 1904.

THE PROPER TIME TO IRRIGATE ALFALFA.

The general appearance, and more particularly the color of the plant, are the best guides, perhaps, as to when water is needed. When healthy and vigorous, alfalfa is of a light-green color; but when the supply of moisture is insufficient the leaves take on a darker and duller shade of green and begin to droop, and unless water is provided both stems and leaves wither and die. Another test is to remove a handful of soil 6 inches or so beneath the surface and compress it in the hand. If it retains its ball-like shape after the pressure has been removed and shows the imprints of the fingers, the soil is sufficiently moist, but if it falls apart readily it is too dry. In connection with such tests it is well to bear in mind that they are more or less influenced by both soil and climate. It is therefore necessary to observe the growth of the plant closely on all new alfalfa fields to determine if possible how far such tests may be relied upon, the chief object being to maintain at all times as nearly as practicable the proper amount of moisture in the soil surrounding the roots of the plants to prevent a checking of their growth.

Alfalfa commonly receives careless treatment at the hands of western irrigators. When water is available and is not needed for other crops it is usually turned on the alfalfa fields or meadows whether these need it or not. There is no question that yields of alfalfa might be considerably increased if more care was used in finding out when to apply water. In each kind of soil and under any given set of climatic conditions there is a certain percentage of soil moisture which will give the best results. Under the present unskillful practice it is impossible to maintain uniform soil-moisture conditions for any length of time. The soil is apt to receive too much or too little water, or else it is deluged with cold water at a time when it needs only heat and air. The number of irrigations required depends upon the depth and nature of the soil, the depth to ground water, the number of cuttings, and the rainfall, temperature, and wind movement. Other things being equal, more frequent waterings are required in the warm sections of the South than in the cooler portions of the North. The number of irrigations per year for alfalfa ranges from 4 in Montana and Wyoming to as many as 12 in parts of California and Arizona. In localities where water is scarce during part of the season the number of waterings as well as the amount used each time depends on the available supply. It is a common practice to apply frequent and heavy irrigations in spring when water is abundant and to water less often and more sparingly when the supply is low.

WINTER IRRIGATION OF ALFALFA.

When water is applied either to bare soil or to crops outside of the regular irrigation season it is termed winter irrigation. The practice thus far has been confined largely to the warmer parts of the arid region. It has become well established in Arizona and California and is being quite rapidly extended to parts of Oregon, Kansas, and the Rocky Mountain States.

Experience has shown that a deep retentive soil is capable of storing a large quantity of water. On account of the fluctuation of western streams of all kinds, from the small creek to the large river, the greatest flow of water often comes at a season when there is least demand for it. In a few localities adequate storage facilities have been provided to retain the surplus, but as a rule it is allowed to go to waste. The passage of so much waste water led to the introduction of winter irrigation and in nearly every case the results have been satisfactory. The chief differences between winter and ordinary irrigations are the larger volumes used, the crude manner of conveying and applying the water, and the dormant or partially dormant condition of the plants at the time of irrigation.

In Fresno County, Cal., water is turned into the canals in January and February. The large canals of the Modesto and Turlock districts run more than half a head during the latter half of February. This is the rainy period in both these localities and the soil is usually too wet for plant growth, but water is applied to alfalfa fields to fill up the subsoil so as to provide a surplus for the rainless summer when water is scarce.

Besides furnishing a supply of much-needed moisture, winter irrigation, when conditions are favorable, prevents winterkilling and improves the mechanical condition of the soil.

WINTERKILLING OF ALFALFA.

The winterkilling of alfalfa is confined chiefly to the colder and more elevated portions of the Rocky Mountain region and to the northern belt of humid States. Damage from cold is rare in Arizona and in California it is confined to young plants. In both the Sacramento and San Joaquin valleys of the latter State the seed is frequently sown in midwinter and the slight frosts which occur occasionally in December and January in both these valleys are severe enough to kill very young plants. The belief is common that the plants are safe after they have put forth their third leaf.

In the colder portions of Montana, Wyoming, Colorado, Utah, and the Dakotas alfalfa is apparently winterkilled from a variety of causes and sometimes from a combination of causes. The percentage of loss around Greeley, Colo., has been placed at 2 per cent per annum. In this locality and throughout the Cache la Poudre Valley in northern Colorado most of the winterkilling is done in open, dry winters and is quite generally attributed to a scarcity of moisture in the soil. In the winter of 1907 considerable damage was done to the alfalfa fields around Loveland, Colo., on account of the long dry spell in midwinter. The old alfalfa fields suffered most. It was the opinion of the farmers that a late fall irrigation would have prevented the loss.

Near Wheatland, Wyo., the higher portions of the fields suffer most damage in winter, and here also the cause is said to be lack of moisture in the soil, combined with the effects produced by cold and wind.

At Choteau, in northern Montana, a farmer watered, late in the fall, part of an alfalfa field which was 2 years old, and it winterkilled, while the unwatered portion escaped injury. This and other evidence along the same line which might be given go far to demonstrate that under some conditions too much moisture is as detrimental as too little.

Probably the chief cause of the winterkilling of alfalfa is alternate freezing and thawing. The damage from this cause is greatly increased when any water is left standing on the surface. A blanket of snow is a protection, but when a thin sheet of ice forms over portions of a field the result is usually fatal to plants. The bad effects of alternate freezing and thawing on alfalfa may be observed at the edge of a snow bank. This crop is likewise injured by the rupture of the tap roots caused by the heaving of the soil.

From present knowledge of the subject, the means which may be used to protect alfalfa fields from winterkilling may be summed up as follows: Where both the soil and the air are dry the plant should be supplied with sufficient water for evaporation, but the land should be drained so thoroughly that none of the top soil is saturated; a late growth should not be forced by heavy irrigations late in the growing season; if the soil is dry, irrigate after the plants have stopped growing; and the latest growth should be permitted to remain on the ground, unpastured, as a protection.

It may be stated in conclusion that the loss to the farmer from the winterkilling of alfalfa is not as great as might appear at first. The damage is done in winter, and there is ample time to plow the plants under and secure another crop, which is usually heavy, owing to the amount of fertilizers added by the roots of alfalfa. The Montana farmer who increased his average yield of oats from 50 to 103 bushels per acre by plowing under winterkilled alfalfa illustrated this point.

SEEDING ALFALFA ON LAND TO BE IRRIGATED.

In Utah the most common practice now is to sow alfalfa without a nurse crop. From 12 to 18 pounds of Utah-grown seed is put in with a 6-inch press drill to a depth of ¾ to 1½ inches during the first half of April. Irrigation before seeding is not necessary, as the soil is usually moist and contains sufficient moisture to support the plants until they attain a height of 6 to 10 inches. At this stage the alfalfa and the weeds are cut about 4 inches above the surface, the cutter bar of the mower being raised for that purpose, and the cuttings are left on the ground. Water is kept off after cutting until the crop begins to suffer. It is believed that when young plants lack moisture they will strike their taproots deeper into the soil in quest of water, and in this way develop a better root system than they would under frequent and copious irrigations. When alfalfa is sown with a nurse crop, oats is preferred. From 10 to 15 pounds of alfalfa seed is sown with 3 pecks to 1 bushel of oats.

In the upper Snake River Valley, in Idaho, alfalfa is usually preceded by a grain crop. The stubble is plowed 6 to 9 inches deep in the fall, and early in the spring it is double-disked, harrowed, and smoothed. From 8 to 20 pounds of seed is then drilled in 0.75 inch to 1.5 inches deep in rows 6 inches apart. When oats is used as a nurse crop it is seeded first, 80 to 100 pounds per acre being used. From 8 to 12 pounds of alfalfa seed are then drilled in, in the opposite direction. Some farmers use a combination drill which seeds both at the same time. When no nurse crop is used the alfalfa plants are clipped when they reach a height of 8 to 12 inches. This is necessary to hold the weeds in check and to cause the plants to stool.

In the Yakima Valley, March and April are preferred for seeding alfalfa, both on account of the climate and the abundant water supply of that period. The ground is plowed deep, graded, smoothed, and harrowed. From 10 to 20 pounds of seed are then put in with a broadcast seeder and harrowed lightly. The furrows are then marked off and irrigation begins. The ground is kept moist constantly until the young plants are fairly well established. The use of so much water at the start is due largely to the tendency of the soil to bake if allowed to become dry.

The alfalfa growers of Montana are about equally divided in opinion as to the advantages of using a nurse crop. Those who seed grain with alfalfa claim that they get more out of the land the first season, while those who are opposed to this practice believe that the injury done to the alfalfa plants by the grain crop extends through several years and that the small gain of the first year is more than offset by the lessened yields of alfalfa in subsequent years.

In northern Colorado, rotation of crops is practiced and alfalfa seed is sown with a nurse crop, usually wheat or barley. The seed is drilled early in the spring with a common force-feed press drill equipped with an auxiliary seed box for alfalfa seed, which is scattered broadcast between the grain rows and covered by the disk wheels of the press drill. From 12 to 20 pounds of alfalfa seed are sown. Irrigation before seeding is not practiced. There is, as a rule, sufficient rainfall to furnish both crops with moisture until the grain is ready to head out and the alfalfa is 4 to 6 inches high, when the field is irrigated.

At Wheatland, Wyo., various methods of seeding alfalfa are in use, but the one which gives the best results may be described as follows: Drill in 1 bushel of barley to the acre; then in a week or ten days cross drill the field, sowing 12 to 15 pounds of alfalfa, setting the press drill so that the seed will be covered 0.75 inch to 1.5 inches deep.

In Yuma and other valleys of Arizona, October planting is preferred. Frequently in this dry climate the land is irrigated before being seeded. It is cultivated, then seeded and harrowed. In the dry-planting method the seed is sown broadcast on the dry soil, harrowed lightly with a brush drag, and then irrigated. A second irrigation is necessary in about eight days to break the surface crust.

In California the treatment given to alfalfa in the first stage of its growth varies somewhat with the locality; in Kern County the seed is sown from December to April, inclusive, with a preference for February and March seeding. If the soil is dry it is first irrigated. In the Modesto and Turlock districts more or less seeding is done throughout the winter months, but the greater part is seeded in March and April, just before the dry season begins. From 30 to 40 acres can be seeded in a day with a hand-broadcasting machine if the operator sits in the back of a wagon which is driven over the field. Eighteen pounds of seed to the acre is the average amount sown.

RISE OF GROUND WATER AND ITS EFFECTS ON ALFALFA.

In their natural state the typical soils of the arid region are characterized by the depth to water and their looseness and dryness. The diversion and use of large quantities of water in irrigation soon change some of these natural conditions. A part of the flow in earthen channels escapes by seepage and still larger quantities percolate into the subsoil from heavy surface irrigations. The waste water from these and other sources collects in time at the lower levels and raises the ground-water level. This rise is usually noticed first in wells, a permanent rise of 5 feet in a year being not uncommon.

This rise of the ground water is an advantage, provided the water table does not rise too high. It lessens greatly the cost of sinking wells, less water is needed in irrigation, and it furnishes a reservoir from which water can be pumped to supply other lands.

It is not until the water level encroaches upon the feeding zone of valuable plants that its injurious effects are felt by the farmer. Its near approach to the surface may prove so disastrous that its upward trend should be noted with the greatest care. Perhaps the best means of providing for such observations is the use of test wells, referred to on page 36.

There is some difference of opinion as to what depth below the surface marks the danger line for alfalfa. It has been shown by Doctor Loughridge, of the University of California, and by other soil physicists that water may be withdrawn by capillarity from soils to depths varying from 4 to nearly 5 feet, depending on the character of the soil. This fact has an important bearing on the subject, because when the ground water is brought to the surface and evaporated the salts held in solution are deposited at or near the surface. If these salts contain much sodium sulphate, or even sodium chlorid, all of which are usually grouped under the common term alkali, the crust formed by them will in time destroy the alfalfa. It may be stated, therefore, that when alkali is present in harmful quantities in the ground water it should not be allowed to rise nearer than 4 feet below the surface.

The percentage of harmful salts in the ground water is usually determined by the chemist of the nearest agricultural experiment station, but when an accurate test can not be made in the laboratory the farmer may make a practical test in the following manner, in accordance with a suggestion made by A. T. Sweet, of the Bureau of Soils of this Department:

Take three pots containing equal amounts of soil and plant the same number of grains of wheat in each. Water each pot with equal quantities of water. In No. 1 apply fresh water, in No. 3 ground water, and in No. 2 an equal amount of each kind. The injury, if any, caused by the ground water will be indicated by the longer time required for the plants to appear above the surface, the smaller number of plants to germinate, and their general appearance.

In soils free from alkali but saturated with water there is not the same necessity for holding the ground water continuously below a so-called danger line. In parts of Kern County, Cal., the ground water sinks to 8 feet below the surface of alfalfa fields in summer, but rises to within 1.5 feet of the surface in winter. There is no indication of root rot and the plants have retained their full vigor. Numerous cases might be cited to show that the rise of water to within a foot or two of the surface for comparatively short periods of time does little injury to the plants. On the other hand, wherever water stands continuously during the irrigation season within a few feet of the surface it is pretty certain to kill alfalfa in three years or less.

THE INJURIOUS EFFECT OF SILT ON ALFALFA AND THE BENEFITS TO BE DERIVED FROM DISKING.

The silt-laden waters of the rivers of the Southwest during periods of high water in time form a crust over the surface of irrigated alfalfa fields. The soil formed by such rivers is naturally impervious, and when a coating of fine sediment is deposited around the plants the effect is injurious, particularly to young plants, which may be killed as a result, notwithstanding the fertilizing value of the silt. In irrigating with water carrying much silt the larger and heavier particles are deposited in the channels which convey the water from the streams, while the finer and lighter particles are carried to the fields. These fine particles cement together and form so hard a crust when dry as to exclude both air and moisture from the soil.

Engineers may in time devise a practical remedy for this evil by building settling basins and storage reservoirs, but at present the tendency of many officers of canal companies is to increase the grade of the channels so as to carry the greater part of the silt to the fields. This does not solve the problem; it merely shifts the burden to the water users. To such, disking the surface at the proper time has proved the most efficient remedy. An effort is made to secure well water or clear ditch water while the alfalfa is young and later to counteract the bad effects of muddy water by the free use of the disk.

Disking alfalfa is quite generally practiced now throughout the West. It is generally done in the spring as soon as the ground is hard and firm and before the growth has started. When a field is disked a second time in the same season it is done when the stubble is short, just after the removal of the crop. The disks should be set nearly straight, so as to stir but not overturn the soil. The spring-tooth harrow is used also, but its tendency is to tear up the ground too much. Perhaps the best implement for this purpose is the spike disk harrow or alfalfa renovator, as it is sometimes called, in which spiked wheels are substituted for the ordinary concave disks.

Disking not only breaks up the impervious layers formed by muddy water, but it splits the old root crowns, thickens the stand, destroys weeds, checks evaporation, and mixes the dead leaves of previous crops with the top layer of soil.

PASTURING IRRIGATED ALFALFA.

Only a small part of the total acreage in alfalfa is pastured throughout any one season, but a large part is pastured during short periods, usually in the fall. Since the plants are easily injured and killed by stock when the ground is wet and soft, stock should be kept off for a time after irrigation. On this account it is a good plan to have the pastures fenced into three equal parts and pasture but one at a time. The inclosures should be alternately pastured, irrigated, and the stand allowed to reach a height of 8 inches or so before stock is turned in again.

PRODUCTION OF ALFALFA SEED UNDER IRRIGATION.

The large area which is seeded to alfalfa each year creates a demand for alfalfa seed. Good seed is grown now in every irrigated State in the West, and the contention that it can not be produced successfully under irrigation is unfounded. The use of too much water is doubtless the cause of many failures. Any one of the crops may be saved for seed, but it requires about twice as long to produce a seed crop as it does a hay crop, owing to the extra length of time required for the seed to ripen, and the different crops do not yield equally well. The more general custom is to save the second crop for seed, and where this is done it is recommended that the first crop be irrigated as usual for hay, and that water should be applied very sparingly, if at all, to the seed crop. Where the same amount of water is used as for hay the growth is rank and rapid, and hay rather than seed is produced.

PROFITS TO THE IRRIGATOR.

The feeding value of alfalfa is so high that the greatest profits can be obtained usually by feeding it to farm animals. When sold in the stack the net profits vary between somewhat wide limits. From the three tabulated statements which follow some idea may be given of the profits to the grower under skillful practice.

Profits from alfalfa growing.

Yakima Valley, Wash.:		
Annual cost of water per acre	$1.50	
Cleaning and repairing farm ditches	.50	
Annual taxes	.75	
Cost of applying water during the season	3.50	
Cost of harvesting and marketing, 7 tons at $2	14.00	
Annual depreciation of hay tools, irrigation structures, etc	1.00	
		$21.25
Average yield of 7 tons, at $7		49.00
Annual profit per acre		27.75

Annual interest on investment 22.2 per cent, on a basis of land and water right valued at $125 per acre.

Parma and Roswell districts, Idaho:

Annual cost of water per acre	$0.50	
Cleaning and repairing farm ditches	.40	
Annual taxes	.60	
Cost of applying water during season	1.50	
Cost of harvesting and marketing, 7 tons at $1.75	12.25	
Annual depreciation of hay tools, irrigation structures, etc	1.00	
		$16.25
Average yield of 7 tons, at $5 per ton		35.00
Annual profit per acre		18.75

Annual interest on investment 18.75 per cent, based on land and water right valued at $100 per acre.

San Joaquin Valley, Cal.:

Annual cost of water per acre	$1.90	
Annual cost of applying water per acre	2.20	
Cleaning and repairing farm ditches	.50	
Annual taxes	1.00	
Cost of harvesting and marketing, 7 tons at $2 per ton	14.00	
Annual depreciation of hay tools, irrigation structures, etc	1.00	
		$20.60
Average annual yield of 7 tons, at $7 per ton		49.00
Annual profit per acre		28.40

Annual interest on investment 16.2 per cent, based on land and water right valued at $175 per acre.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 374.

Experiment Station Work,

LIII.

Compiled from the Publications of the Agricultural Experiment Stations.

INOCULATION AND LIME FOR ALFALFA.
CITRUS CULTURE IN SOUTHERN TEXAS.
PRUNING ROTUNDIFOLIA GRAPES.
NATIVE HAYS OF ARID REGION.
BERMUDA GRASS.
SHORT v. LONG FEEDING OF BEEF CATTLE.
CONTAGIOUS ABORTION OF CATTLE
PREVENTING LOSSES AT LAMBING TIME.
WINTER LAMBS FOR THE PACIFIC COAST MARKET.
FEEDING WORK HORSES.
COLONY HOUSES FOR POULTRY.
FOOD OF THE CROW BLACKBIRD.
FLOUR FOR BAKING POWDER BISCUITS.

JULY, 1909.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

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1909.

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EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief objects of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

CONTENTS OF NO. LIII.

Page.

Inoculation and lime for alfalfa 5
Citrus culture in southern Texas 7
  Oranges 8
  Grape fruit 8
  Lemons 8
  Kumquats 8
  Citrus trifoliata as stock 9
  Selection of soils 9
  Preparation and cultivation of the soil 9
  Cover crops 10
  Freezes 10
Pruning rotundifolia grapes 11
Nutritive value of native hays in the arid regions 12
  Wheat grasses 13
  Wire grasses 14
  Sweet-clover hay 15
  Saltbush 15
Bermuda grass 16
Short *v*. long feeding of beef cattle 17
Contagious abortion of cattle 19
Preventing losses at lambing time 22
Winter lambs for the Pacific coast market 25
Feeding work horses 25
Colony houses for poultry 26
Food of the crow blackbird 30
Flour for making baking-powder biscuits 31

374

A study of the influence of the inoculating soil in the experiments for 1907 revealed that of 36 check plats 10 produced a successful yield of hay, while among an equal number of adjoining inoculated plats 18 gave successful yields. The influence of the inoculation was not limited to the fields which were changed from a failure to a success, but was noticeable on practically all fields except where the proper bacteria were already present in sufficient numbers. In a summary of the results for the three years it is shown that of 103 experimental fields only 25 yielded a successful crop of alfalfa without the use of inoculating soil, while of the adjoining plats to which inoculating soil had been applied 66 gave successful yields. The number of successful fields is here increased by 40 per cent as apparently due to the use of inoculating soil.

The results with reference to lime in 1907 showed that in 10 of 37 experiments profitable crops of hay were secured without its use, while of the adjoining plats treated with lime 18 produced profitable crops. Lime quite generally improved the yield. Taking the three seasons together, an improvement resulted in 54 of 64 fields under test. Only 11 of the unlimed plats gave profitable results, while 27 of the adjoining plats treated with lime produced successful crops. In these 64 tests the use of lime by itself increased the number of successful fields by 25 per cent, and all the fields giving good yields without lime were improved by its use. In no case did this moderate application of lime show any detrimental effects. While these results establish the principle that liming is generally profitable with alfalfa in New York, they do not solve the problem as to the most profitable quantity of lime to use; and as this varies for different fields, it must be worked out for each field by the farmer himself. Tests with litmus paper to determine whether or not a soil needs lime seemed to indicate that little information of value can be gained from this method.

Reliable data on the combined action of inoculation and lime were secured from 65 experiments. In this series only 12 of the untreated check plats produced a satisfactory crop of alfalfa, while of the adjoining plats, inoculated and limed, 50 were a success. The combined treatment had increased the chances of success from 18 per cent on the check plats to 77 per cent on the treated plats, or an increase of 59 per cent as apparently due to the treatment.

These experiments were generally conducted on land well drained, fairly fertile, and quite clean. The seed used was previously examined for dodder, trefoil, and other injurious weed seeds. It is concluded from the results that under these conditions the natural lack of inoculation and of lime is largely responsible for the difficulty experienced in obtaining a satisfactory stand of alfalfa in different parts of the State. The lack of lime was very general, practically all fields responding to its application, but the lack of the proper bacteria was more often the controlling factor, since inoculation changed more than twice as many fields from failure to success as did the use of lime.

Attention is called to the fact that when land is already sufficiently provided with the required bacteria, inoculation is without any apparent effect upon the crop and that when sufficient inoculation is lacking the use of 150 to 300 pounds per acre of soil from an alfalfa field producing plants with nodules will supply the necessary bacteria. Inoculation and lime are effective only in so far as they are needed and are capable of doing little in producing a good stand and a profitable yield if other necessary conditions such as proper drainage, sufficient fertility, a clean soil, adequate tillage, and good seed are not provided.

Briefly summarizing the results it is found that without either lime or inoculation the chance of a successful crop is not more than 20 per cent, or one chance in five; with lime the chance of success is raised to 40 per cent, or two in five; with inoculation it is raised to about 60 per cent, or three chances out of five; while both lime and inoculation used together indicate a successful crop about four times out of every five trials.

CITRUS CULTURE IN SOUTHERN TEXAS.[a]

With the recent active horticultural development in southern Texas there has arisen a demand for information relative to the adaptability and culture of the various citrus fruits in that region.

The culture of citrus fruits in the Gulf coast region generally has been rather fully discussed in a previous Farmers' Bulletin of this Department,[b] but in a recent bulletin of the Texas Agricultural Experiment Stations, S. A. Waschka gives an account of the experimental plantings of oranges, grape fruit, lemons, and kumquats at the Beeville Substation, together with information gained from plantings made elsewhere in the same region, which it is believed will be useful to the large number of people who have undertaken to grow citrus trees in southern Texas.

None of these plantings, however, are very old, and as Mr. Waschka says, "for the last five years, until the cold spell in January of this year (1909), the coast belt has not been visited by weather severe enough to test the endurance of the citrus trees." In January past the trees withstood a temperature which went as low as 20° to 24° over most of the citrus-fruit belt. This is considered an encouraging circumstance for the development of the industry.

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[a] Compiled from Texas Sta. Bul. 118. [b] U. S. Dept. Agr., Farmers' Bul. 238.

ORANGES.

In March, 1907, 30 varieties of 1-year-old orange trees were planted at the station. Of these the following varieties were bearing some fruit in 1908: Satsuma, Dugat, Washington Navel, Mandarin, Mediterranean Sweet, and Parson Brown. Other varieties are expected to bear during the present year. The experience of longer standing has been practically confined to two varieties of oranges, the Satsuma and the Dugat, garden plantings of which have been grown in southwest Texas for some considerable time with apparent success.

> The Satsuma is the hardiest, and will resist more cold than any other orange. So far as our experience goes, the Dugat is the next hardiest. We have had more experience with these two than with any other variety. They are young and heavy bearers, and the fruit of both is excellent for market. The Dugat has produced 200 nice marketable oranges when the tree was 3 years old, and 250 when the tree was 4 years old. The Satsuma will do about the same thing if properly cared for.

GRAPE FRUIT.

Grape fruit is not extensively planted in Texas, principally because it is not so well known as the orange. The following five varieties of grape fruit have been tried at the station thus far, all of which have proven to be heavy bearers the third year after planting: Triumph, Tresca, Duncan, Pernambuco, and Royal. The yields varied from 137 well-matured fruits on 4-year-old Triumphs to 648 well-matured fruits on 4-year-old Royal trees. Some of the individual fruits of the Tresca variety measured 5½ inches in diameter. In general the fruits averaged about 4½ inches in diameter.

LEMONS.

The station tested only one variety of lemon, the Villa Franca. This proved to be a young, prolific bearer. The fruit "is excellent in size and quality, and will doubtless secure a permanent place in the markets. One-year-old trees planted in February, 1904, yielded as high as 164 lemons of excellent quality in 1908." It must be borne in mind, however, "that the lemon is not so hardy and resistant to cold as the orange and the pomelo."

KUMQUATS.

Relative to kumquats, which are dwarf members of the citrus family and of value chiefly for ornament and as pickles, Mr. Waschka has the following to say:

> We have grown two varieties of the kumquats, both of Chinese origin. The *Nagami*, oblong in shape, measuring about 1½ by 1¼ inches in diameter. The fruit of the *Marumi* variety is round, slightly flattened, and somewhat smaller than that of the

Nagami. The kumquat, when ripe, has a perfect orange color, rather acid, but very aromatic, and is an excellent relish. The Nagami bears fruit mostly in clusters, and when cut with leaves attached forms a very attractive table decoration. Both varieties make excellent preserves, and wherever known are in great demand. For market the fruit is usually packed in quart baskets and crated like strawberries or tomatoes. The trees are dwarfed, if, in fact, they may be considered trees, attaining a growth from 8 to 12 feet in height, and two-thirds this measurement across the head. They are very young and prolific bearers, setting a crop of fruit the first year after planting, comparing favorably in this respect with the Satsuma oranges, their hardiness being increased by using trifoliata stock to bud on. The low, dwarfish heads of the tree provide a great deal of protection to the trunk.

CITRUS TRIFOLIATA AS STOCK.

On account of its hardiness, *Citrus trifoliata* is recommended as a stock to be used in southern Texas for all citrus trees, since, "to some extent, it seems to impart some of its hardiness to the scions worked upon it. The trees budded on this stock come into bearing at an earlier age, as a rule, and produce their fruit early in the season. * * * It has been claimed that the trifoliata stock dwarfs the tree, but this seems to be an error."

SELECTION OF SOILS.

The following advice is given relative to the selection of soils for citrus culture:

It may be said that the citrus trees are apparently not very fastidious as to the type of soil best suited to them, and this is especially true if the right stock is chosen to work them on. Still, there are certain soils upon which we would not advise that they be grown. Sticky, heavy soils should be avoided for commercial groves. These soils are fertile enough, but they easily become dry and compact, unless under irrigation, and then they are more likely to become puddled or tamped and difficult to work. Soils that are not properly drained must, of course, be avoided; or soils that have hardpan are unsuitable, unless the hardpan is broken up so that the roots of the soil may easily penetrate it. Citrus trees are generally surface feeders, but still provision must be made for the roots to penetrate to such a depth as will firmly anchor the tree in the soil. The trees succeed best on well drained, loose soils, preferably, perhaps, on a sandy loam that gradually changes into a heavy loam, underlaid by pliable clay, 18 inches or more from the surface. Extremely open, porous soils are not desirable. A pure sandy loam, with a clay subsoil, is well suited, provided it is properly enriched by the application of fertilizers.

PREPARATION AND CULTIVATION OF THE SOIL.

The land should be thoroughly prepared as for any other crop. It should be deeply plowed—if the rainfall is low—and pulverized by harrowing and smoothing. If sod land is to be used, it is best to break it about three times, say, 3 inches the first time, followed by disk harrow, and then followed by a lever or section harrow. The second plowing may be carried 5 or 6 inches deep, harrowed as in the first instance. In semiarid districts the third plowing should be as deep as practicable, say, 7 to 10 inches, and harrowed as before. It is preferable, of course, that the land be prepared as above before the trees are set out.

Mr. Waschka emphasizes the importance of thorough cultivation for the conservation of the soil moisture in dry climates or dry periods and the need of proper drainage in wet weather:

> Proper cultivation at the proper time is often equal to irrigation; in fact, it is at times better, because if irrigation is not properly conducted it may work positive injury. Cultivation should be followed after each rain, or after each irrigation, if this be practiced. The ground should be properly worked with a harrow, or, if need be, with a cultivator, after every rain, in case the locality is one where the conservation of moisture is an important consideration. In fact, in such localities it is a good practice to keep the cultivator or harrow going during the dry season, say, to the middle of September, after which cultivation should cease, in order that tree growth may be checked and the wood hardened for the winter. Very deep plowing is not advisable after the tree begins to grow in the spring, but a plow may be used to advantage at some distance from the tree, and at some greater depth than the shallow cultivators give. The plow may be used even in December, but great care should be taken not to tear up the roots of the tree. Weeds of any kind should not be allowed to grow in the orchard at any time

COVER CROPS.

The use of a leguminous cover crop is advised, "even though the land is rich in nitrogen, humus, and other plant food," for "such crops make the soil loose and mellow and prevent surface washing during rainy seasons, and at the same time regulate the moisture of the soil." The practice at the station has been to plant the cowpeas in rows about 3 feet apart and to cultivate them as long as the vines will permit. The vines are not allowed to run closer than 5 feet from the trees, so that the latter may be properly cultivated. "It is best to plant peas early in the spring, and, when the first pods are ripe, cut up the crop and soil with a disk harrow."

FREEZES.

Although the winter climate in southern Texas is usually mild, the occurrence of severe freezes of short duration are by no means uncommon, and the trees should be given some sort of protection every year.

> It is very essential to bank around the trees for winter, in order that a portion of the trunk may be preserved in case of a severe freeze. Should the trees get winter killed they should be cut back in the spring as far as they have been frozen, leaving the healthy wood to produce sprouts and make another tree, which they will do in two or three years. These mounds of earth should be removed as soon as all danger of a severe freeze is past—say, about the 1st of March. In the Gulf coast section of Texas, the trees may, as a rule, be left unprotected until about the 1st of December. Nothing but clean earth should be used in banking, and a considerable portion of the tops should be left exposed.

In a recent article dealing with the possibility of orange culture in South Texas, H. M. Stringfellow[a] called attention to the fact that

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[a] Orange Trees for Texas. H. M. Stringfellow: Texas Farm and Ranch, 28 (1909), No. 2, pp. 10–12.

that section had been visited by killing freezes of short duration at irregular intervals several years apart. Among the methods suggested for the protection of tree tops, he advocated the trial of sheet asbestos as a wrapping for the trunk of the tree. A small mound of earth should be drawn up around the bottom of the wrapping, and a little cotton should be stuffed between the tree and the wrapping at the upper end in order to prevent the circulation of air beneath the wrapping.

In conclusion it may be said that the only drawback to commercial citrus culture in southern Texas which is worthy of serious consideration is that of the possibility of occasional spells of severe freezing weather. If, as has been the case in recent years, the interval between the periods of killing frosts is sufficiently long to permit of harvesting three or four crops of fruit, the industry might be placed on a paying basis in spite of the freezes, since citrus fruits in southern Texas come into bearing very early. Thus far, however, it appears that the Mandarin type of orange, which includes the Satsuma and Dugat, above mentioned, as well as several other varieties, is the only safe kind to plant in this section. Plantings of the ordinary sweet oranges, such as are grown in California and Florida, should be done merely in an experimental way. It might also be well to consider to what extent the market will call for oranges of the Mandarin type. It is quite possible that such varieties could soon be overplanted.

PRUNING ROTUNDIFOLIA GRAPES.[a]

The scuppernong and other rotundifolia or muscadine grapes of the South are usually grown on arbors and allowed to ramble at will, since pruning is commonly considered detrimental to them. As a result, the vines become matted in the course of a few years and do not yield well except on the outer edges of the arbor. The vine-clad arbor is often valuable in providing a shady retreat about the home grounds and sometimes even for protecting stock from the sun. These grapes can be grown for market, however, to greater advantage and profit on wire trellises. Whether grown on arbor or trellis they will succeed better if rightly pruned. In a recent bulletin of the South Carolina Station, C. C. Newman says:

> To succeed in growing these grapes on an arbor or trellis we must prune freely every fall and never allow the vines to grow in masses. When the vines become too thick it is better to remove a few of the large canes rather than cut out a great many small ones. When the small canes are cut out it only relieves the trouble temporarily, as it induces them to branch freely and the vine becomes thicker than ever.

By conducting the sap through a rubber tube to a large glass jug Professor Newman compared the amount of sap lost through pruning vines at different periods. The following table shows the amount of sap collected from vines that were cut at different periods from October 20 to May 21:

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[a] Compiled from South Carolina Sta. Bul. 132.

Sap lost from scuppernong vines pruned at different dates.

Date vines were cut.	Diameter of vine cut.	When bleeding began.	When bleeding ceased.	Amount of sap lost by each vine.
	Inches.			
October 20	½	No bleeding	No bleeding	None.
Do	1	do	do	Do.
November 21	½	do	do	Do.
Do	1	do	do	Do.
December 19	½	Feb. 18	May 1	2 ounces.
January 20	½	do	May 15	9 pounds 4 ounces.
February 21	½	Feb. 21	May 18	31 pounds 3 ounces.
March 20	½	Mar. 20	do	23 pounds 5 ounces.
Do	1	do	May 25	23 pounds 6 ounces.
April 20	½	do	May 10	12 pounds 4 ounces.
May 21	½	No bleeding	No bleeding	None.

These results show that—

If the vines are pruned during the months of October and November there will be no injurious effects, but if they are cut later in the season, they will bleed badly and seriously injure if not destroy the vine.

If the pruning is delayed until after December, there will always be more or less injury to the vine caused by the loss of sap in the spring. After the vines have made a growth of from 5 to 6 inches in the spring, small vines may be cut without causing serious injury, but the large vines will bleed badly even at this season. Vines cut in late winter will not bleed until the weather begins to turn warm, but will then bleed freely. They will cease to bleed if the weather turns cool again, only to bleed more freely as the spring advances. A vine that has been pruned too late in the season will be so weakened by the loss of sap that it will be a week or ten days later in starting to grow than vines pruned in the early fall.

NUTRITIVE VALUE OF NATIVE HAYS IN THE ARID REGIONS.[a]

Practical stockmen in the arid West declare that the native grasses and forage plants are the most nutritious in the world and point to the condition of their animals as offering abundant evidence of their assertions. It is a common practice among many ranchmen to flood their meadows during the irrigating season to such an extent that many of the true grasses are killed, so that the hay harvestings are often composed largely of rushes and sedges, which give a greater yield than hay made from grasses. In the past few years several experiment stations in that region have undertaken investigations to compare the nutritive value of the different grasses, sedges, rushes, and other native forage plants.

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[a] Compiled from Colorado Sta. Buls. 93, 124; Nevada Sta. Buls. 62, 64; Wyoming Sta. Buls. 65, 68, 69, 78, 79.

The Nevada Station conducted experiments to determine the nutritive value of hay in different portions of the stalk and of the second-growth crop of native hay of the Truckee Meadows when fed to sheep.

These plants vary considerably in their feeding value. Owing to the unevenness of the land and the methods of irrigation in vogue, some parts of the fields receive a much larger amount of water than others. In the lowest places the water grasses, sedges, and rushes predominate, while in the higher parts the true grasses and clovers are more abundant. In consequence of this, a stack of native hay does not represent a uniform feeding value throughout. That portion of the stack composed largely of the native bluegrasses and clover is of a much better quality than that composed almost entirely of water grasses, sedges, and rushes. The rancher from whom we purchased the hay was anxious to find out the nutritive value of his hay and especially of the second-growth crop. This second crop is cut long before maturity and consists of the young, tender portions of the grasses, sedges, rushes, and clovers that have been produced after the removal of the first crop. It is strictly speaking the aftermath. The stockmen to whom he sold his hay in the fall and winter season for fattening sheep and cattle for market differed widely in their opinions as to the feeding value of this second crop. Some feeders regarded it highly, while others considered it worthless.

The botanical composition of the four samples was examined. The first sample, which consisted of second growth native hay, contained no plants which had reached maturity. The clover sample consisted largely of the introduced alsike clover and a native clover (*Trifolium spinulosum*). The bluegrass sample contained a great variety of grasses, but Buckley bluegrass (*Poa buckleyana*), alkali meadow grass (*Puccinellia airoides*), and spike rush grass (*Eleocharis arenicola*) predominated. The timothy sample consisted largely of timothy and tickle grass (*Hordeum jubatum*). About one-half of the wire-grass sample consisted of common wire grass (*Juncus balticus*) and brown-top sedge (*Carex athrostachya*).

Many native grasses, legumes, and forage plants are described in bulletins of the Nevada and Wyoming stations, and results of chemical analyses are given, which show them to be rich in nutritive constituents. The chemical composition alone, however, is not enough to determine the actual food value. It is the object of this article to summarize the work done at these experiment stations on the nutritive value of these native plants. At the Wyoming Station feeding experiments with sheep, begun in 1904 and continued up to the present time, show that the practical man is right in believing that these native grasses are fully as nutritious as the tame grasses of the East.

WHEAT GRASSES.

In one experiment with wheat grasses 10 Shropshire and 10 Merino lambs were fed for sixteen weeks on alfalfa, corn, and turnips, and made a gain of 31.2 pounds per head at a cost of 4.6 cents per pound. With another lot of lambs the alfalfa was replaced with an overripe and woody hay made from Western wheat grass (*Agropyron occidentale*). These lambs made an average gain of 20.7 pounds per head at a cost of 6.08 cents per pound. From later experiments with mixtures of wheat grasses it would appear that they are more nutritious than in the experiment previously quoted. "Practical experience has proven that the Western wheat grass is an excellent fodder, and results show that it is more nutritious pound for pound than timothy, which commands a higher price in western markets. There may be several reasons for favoring timothy, one of which is that it is very difficult to grow Western wheat grass free from foxtail, which depreciates the value of the crop, because of the injuries inflicted by foxtail upon animals feeding upon it. Then there is a prevalent idea that timothy is the only hay that should be used for horse feed." On the bottom lands along the water courses in Colorado there is a grass closely allied to the Western wheat grass and known locally as Colorado bluestem (*A. tenerum*). Samples of mixed hay containing a large proportion of this grass were obtained near Fort Collins and in the Box Elder Valley and were used for experiments at the Colorado Experiment Station. The Fort Collins sample was much more digestible, as is shown by the accompanying table.

WIRE GRASSES.

Three sheep were used for digestion experiments with wire grasses, which were composed mostly of rushes and sedges. Out of 100 pounds of wire-grass hay about 50 pounds of the native hay was digested and assimilated. The digestibility of the protein was surprisingly low. Evidently the hay fed in this experiment was inferior to much of the hay used by stockmen.

> In one feeding trial with small lots of lambs upon various grain rations and native hay [composed largely of wire grasses] the ration made up of native hay, oats, and oil meal proved to be the best of those tried, the lambs making a gain of 17.4 pounds per head in fourteen weeks, against 28.6 pounds made by the lot on alfalfa hay and corn. [Another experiment] with 40 lambs in each lot shows an average gain of 20.3 pounds in fourteen weeks by the lambs on native hay, oats, and oil meal, and 34.3 pounds by the lambs on alfalfa hay and corn.
>
> The amount of feed required was 607 pounds of native hay, 460 pounds of oats, and 25 pounds of oil meal for 100 pounds of gain. In the previous experiment 574 pounds of hay, 591 pounds of oats, and 86 pounds of oil meal were required for 100 pounds gain.
>
> The results of these two experiments indicate that the native hay, oats, and oil-meal ration will produce somewhat less than two-thirds the gain produced by alfalfa hay and corn in the same length of time, and also requires considerably more feed to produce 100 pounds gain.

SWEET-CLOVER HAY.

In the South sweet clover is prized as an early pasture for sheep. Throughout the Eastern States it is regarded as a weed. In some sections of the West it is used as a pasture for pigs. At the Wyoming Station its digestibility as a sheep feed has been investigated.

At this altitude, under the peculiar conditions, it is believed by a few that there is a future for it since it grows well. It is an alkali-resisting plant, and although it is not palatable to stock in the green condition, yet after it is cured, especially where salt has been added, the stock relish it and thrive well upon it. It is very nutritious, readily digestible, and contains an exceedingly high percentage of crude protein. It is more nutritious when cut at the proper period than many of the other hays.

The sweet-clover hay used in this experiment was grown on the experiment-station farm near Laramie in 1905. It had been in stack for over a year before being used for this experiment. It was very rank at the time of cutting and the amount of stems, therefore, very large in proportion to the leaves. The stems had become rather hard and woody. Notwithstanding this, the hay proved to be a very narrow ration, since the nutritive ratio was only 1:3.2. The crude fiber did not run as high as would have been expected, being but 24.75 per cent.

A lot of 10 lambs that were fed on white sweet-clover hay, corn, and oil meal made an average gain of 30.7 pounds in fourteen weeks, while 10 lambs fed on alfalfa hay and corn made 34.4 pounds gain. "The former ate one-sixth more hay, somewhat more corn, and a small amount of oil meal. The larger consumption of sweet-clover hay was due to the fact that it was cut late and was very coarse and stemmy. The lambs liked it, however, and showed a steady appetite for it. There was not the slightest difficulty in getting them to eat it at the start."

SALTBUSH.

The nutritive value of the saltbush (*Atriplex argentea*), used by the ranchmen, has been studied in sheep feeding experiments at the Colorado Experiment Station. "This saltbush is not to be mistaken for the Australian saltbush (*A. semibaccata*), which plant differs materially from *A. argentea*. The Australian saltbush has been recommended by the California Station as a forage plant in alkali soils." In tests made at the Wyoming Station this plant gave better results than the native silvery saltbush, but was not found to be a really good fodder. A chemical analysis indicates no reason except an abnormally high ash content why the native saltbush hay should not be at least a fairly good feed. The amount of ash, though large, is less than is found in the dried leaves of the sugar beet, which are fed, with excellent results, to both cattle and sheep. The results of the feeding experiment were, however, not favorable, as each of three sheep used in the experiments lost weight, one sheep losing one-half pound, one 2 pounds, and the third 6 pounds.

For convenience of comparison and reference, the results of digestion experiments with the various forage plants are collected in the following table:

Digestible nutrients in 100 pounds of air-dried native hays.

Sample.	Protein.	Fat.	Nitrogen-free extract.	Fiber.	Nutritive ratio.
Western wheat grass (Wyoming):	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1904	3.81	1.09	33.32	20.69	1:14.88
1908	4.42	1.44	30.44	18.97	1:9.6
1908	4.15	1.42	31.48	20.29	1:13.2
Wire grass (Wyoming):					
1904	4.58	1.33	30.59	18.82	1:11.48
1906	2.25	1.07	28.85	18.68	1:20.9
Sweet-clover hay (Wyoming)	11.88	.49	28.36	8.32	1:3.2
Second growth native hay (Nevada)	6.49	2.96	56.96	....	1:9.3
Clover sample (Nevada)	4.10	1.85	53.75	....	1:14.1
Bluegrass sample (Nevada)	3.48	2.36	53.02	....	1:17
Timothy and tickle grass (Nevada)	5.06	2.11	59.16	....	1:12.6
Wire grass (Nevada)	3.90	2.56	51.75	....	1:14.7
Blue stem (Fort Collins sample)	4.48	.76	25.86	22.18	1:11.1
Blue stem (Box Elder Valley sample)	4.34	.64	21.92	17.43	1:9.4
Saltbush (Colorado)	6.46	.76	17.88	2.27	1:3.2

BERMUDA GRASS.[a]

The success which has been attained at the Oklahoma Station with Bermuda grass as a pasture and hay plant has been briefly referred to in previous bulletins of this series.[b] From a recent bulletin of the Oklahoma Station on this subject, prepared by L. A. Moorhouse and others, the following summary is taken:

> Bermuda grass is a native of tropical countries; however, it can be grown as far north in this State as the Kansas line. A few samples of Bermuda grass roots have been distributed in southern Kansas. Even if it is possible to start Bermuda by sowing seed, the crop should be propagated entirely by planting root cuttings.
>
> Recent experiments appear to indicate that Hardy Bermuda grass, a type which has been developed by the experiment station, is a selection well adapted to Oklahoma conditions. Many farmers are planting this grass not only for the purpose of preventing soil erosion on roadsides and on very rolling fields, but they are also securing sets in order to provide the live stock of the farm with suitable pasture throughout the hot summer months.
>
> Unless the soil is well prepared, the grower can not expect to secure a complete stand if unfavorable weather conditions prevail. During the month of May the rainfall is usually abundant, hence this is the best time of the year to plant Bermuda roots. A suitable temperature is an essential feature in starting this crop.
>
> After the soil has been placed in good tilth, the roots or sods may be dropped in rows which are 30 to 36 inches apart; 18 inches is a suitable distance for spacing the pieces in the row. Grass which has been down several years may be improved by cultivation and manuring.
>
> Reviewing the experiences of a large number of growers we find that this grass is regarded with favor in many widely separated districts. A few observations with white clover which was sown on a Bermuda-grass lawn have given us some reason to

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[a] Compiled from Oklahoma Sta. Bul. 85.

[b] U. S. Dept. Agr., Farmers' Buls. 281, p. 10; 320, p. 12.

believe that these two plants can be used as a pasture mixture with profit. Some feeding tests have been made with Bermuda hay; it compares very favorably with such standard types as timothy or Kentucky blue grass.

Since this grass reproduces by underground root stems as well as by seed, some have thought that eradication would be impossible; however, by adopting the proper plan, this grass may be destroyed and other crops can be grown upon the same area. In planting roots the grower should confine this grass largely to areas which are to be used for permanent pasture.

As regards eradication, it is stated that while "Bermuda grass should be planted only on those areas which are to be used for permanent pastures, there may be cases where it is expedient to plow up the grass after it has become firmly established. In such cases quite thorough treatment must be given. The soil should be turned to a depth of 3 or 4 inches during the latter part of November or early in December. The turf may remain exposed to the frosts of winter and thorough surface cultivation can be given in the spring of the year. A crop which will produce a dense covering or shade should be selected and planted. Cowpeas or sorghum answer well for this purpose. Bermuda grass does not thrive in the shade; thus the winter exposure and the check which is placed upon it during the summer months will assist in destroying the major portion of the crop."

A circular of the Bureau of Plant Industry of this Department [a] makes the following suggestion regarding the eradication of Bermuda grass:

> The very qualities which render Bermuda so valuable as a pasture grass serve to make it an aggressive and pestiferous weed. On account of its tendency to spread and insinuate itself into the land where it is not wanted and to persist in fields which are to be used for other purposes, it has in many cases not been utilized to the extent that its good qualities would indicate. However, it can be eradicated from a field with comparative ease by proper cultivation. Since it will not thrive in the shade, it is only necessary to smother it out by some quick-growing crop. The method recommended by southern agriculturists and which may be modified to suit conditions is to plow the land after the last crop of hay is cut, if the field is a meadow, or about this season if it is a pasture. Sow the field to oats, wheat, or to some thick-growing crop. When this crop is harvested, plow the land immediately and plant to cowpeas. It is probably best to plant these in drills and cultivate them until the vines meet, after which they will shade the ground and prevent the growth of Bermuda. Usually this treatment is sufficient to destroy the Bermuda completely, but if not, the process can be repeated.

SHORT VERSUS LONG FEEDING OF BEEF CATTLE.[b]

Since the prices for feed stuffs have been so high there has been a tendency in the Central West when purchasing feeders to buy mature cattle and thus shorten the feeding period. This method of feeding has given rise to the term "short-fed cattle." At the Indiana Station experiments have been in progress the past two years to ascertain the comparative profits secured from feeding cattle by the two methods. In the two series of experiments reported two lots of 10 steers each were fed shelled corn, cotton-seed meal, clover hay, and corn silage.

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[a] U. S. Dept. Agr., Div. Agrostology Circ. 31.

[b] Compiled from Indiana Sta. Bul. 130; Ann. Rpt. Ontario Agr. Col. and Expt. Farm, 34 (1908); Canada Expt. Farm Rpts. 1906.

Two lots of cattle were started on feed at the same time each year. The "long-fed" steers used averaged at the beginning of the first test 1,010 pounds, and would have graded as good, fleshy feeders; the "short-fed" steers averaged 1,175 pounds and were carrying too much flesh to be classified as feeders, but would have been sold as killers if placed on the market at the time they went into the experiment. * * * The first test began November 21, 1906, and closed for the "short-fed" lot February 19, 1907; for the "long-fed" lot, May 20, 1907. The second test started November 17, 1907, and closed for the "short-fed" cattle March 15, 1908, and for the "long-fed" cattle May 15, 1908. * * * The variation in the price of corn during the two winters when the work was conducted, together with the fluctuation in the price of fat cattle, makes it necessary to use different prices in computing profit or loss from feeding. In the financial statements corn is valued at the prevailing market prices at the time of feeding; cotton-seed meal at $28 per ton, clover hay at $10 per ton, and corn silage at $2.50 per ton.

In the experiments of 1906–7 the average daily gain per head for the long-feeding period was 2.57 pounds, at a cost of 7.59 cents per pound, and for the short period 3.16 pounds, at a cost of 6.98 cents per pound, estimating corn to be worth 40 cents per bushel. In 1907–8 the corresponding average daily gain of the long-fed steers was 2.66 pounds per head, at a cost of 7.91 cents per pound, and of the short-fed steers 2.85 pounds, at a cost of 7.83 cents per pound.

In the first test the total amount of corn necessary to finish each steer was 34 bushels in the "short-fed" lot and 54.6 bushels in the "long-fed" lot; in the second test, 42.5 bushels in the "short-fed" lot and 61.1 bushels in the "long-fed" lot.

In the first test it was necessary to put on 285 pounds per head in the "short-fed" lot and 464 pounds in the "long-fed" lot to attain the same marketable finish; in the second test 318 pounds in the "short-fed" lot and 479 pounds in the "long-fed" lot.

During the period when both lots of cattle were in the feed lot there was a greater profit per head from feeding the heavier, fleshier steers.

In the first test the margin necessary to prevent loss on the "short-fed" cattle at the time of marketing was 48 cents per hundred; on the "long-fed" cattle at the same time 50 cents, and on the "long-fed" cattle at the time of marketing $1.04 per hundred.

In the second test the margin necessary to prevent loss on the "short-fed" cattle at the time of marketing was 92 cents per hundred; on the "long-fed" cattle at the same time $1.01 per hundred, and at the time of marketing $1.54 per hundred.

The cost of gains was cheaper on the thinner cattle during the first three months of the test, but when fed to the same marketable finish the cost of gains was practically the same.

In short feeding cattle for late summer and fall markets it is necessary to start with very fleshy feeders of excellent beef type in order that they will not sell in competition with western grass-fat cattle.

During the winter of 1907–8 there was a marked improvement in cattle values between the time of marketing the "short-fed" and "long-fed" cattle, which makes a showing in favor of the long period very much better than it would be if prices had remained stationary.

* * * The data presented * * * clearly show that lighter and thinner cattle make cheaper gains than heavy, fleshy feeders if fed the same length of time, but where fed to the same marketable finish the cost of gains will be practically the same; that heavy, fleshy feeders, suitable to be finished in 90 to 110 days, will cost practically 50 cents more per hundred than cattle similar in every respect except that they do not carry so much flesh; that the difference in cost of the fleshy feeders and light thin feeders both during the fall of 1906 and 1907 was not great enough to offset the difference in the cost of making gains in the feed lot. This shows that it is generally cheaper to buy flesh on the feeders than to put it on in the feed lot. It was necessary to put on 464 pounds during the first test and 479 pounds during the second test on the "long-fed" cattle, and 285 pounds in the first test and 318 pounds in the second test on the "short-fed" cattle, while in the feed lot, to make them equally fat. It was necessary for the "short-fed" cattle to increase in value 16.6 cents per month for a three months period, while it was necessary for the "long-fed" cattle to increase 17.5 cents per month for a six months period, with corn at 40 cents per bushel, in order to break even on feeding cattle without counting the value of either hogs or manure.

Experiments in feeding short versus long periods have been conducted at the Ontario Experiment Station for several years. In one of the later experiments 8 steers fed for 77 days made an average daily gain of 2.25 pounds. The same number of steers fed for 160 days on the same ration made an average daily gain of 2 pounds. During the 3 years these experiments have been in progress the short-fed steers as a rule have returned higher prices per steer than the long-fed steers. At the Canada experimental farms the best results have sometimes been obtained with the long-fed steers. In one case 7 steers fed for 180 days gained 2.36 pounds per day, at a cost of 4.26 cents per pound, while a similar lot of 8 animals fed for 130 days gained at the rate of 2.08 pounds per head per day, at a cost of 4.85 cents per pound.

On the whole, these results at the different experiment stations are to the advantage of the short-fed steer, but a change in market conditions might easily reverse the situation. For some time there has been a good demand for the short-fed steer, and feeders have been inclined to let them go in an unfinished condition. These conditions may not hold for any length of time, for if too many join the ranks of short feeders the price of short-fed cattle may not be commensurate with the long-fed, as there are some consumers who demand prime beef from the finished steer. The success of the feeder will depend on his skill in buying, feeding, and in forecasting market conditions.

CONTAGIOUS ABORTION OF CATTLE.[a]

This is a disease with which every cattle raiser and dairyman should be acquainted, as it is liable to be introduced into his herd, and a all discharge is stopped. It is somewhat risky to use this treatment with pregnant cows, but in this case a tablespoonful of sodium hyposulphite, once in twenty-four hours, should be given as a drench. All of these, with directions for using, may be obtained at nearly any drug store.

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[a] Compiled from Arizona Sta. Bul. 51; Connecticut Storrs Sta. Rpt. 1907, p. 139; Kansas Sta. Bul. 136; U. S. Dept. Agr., Bur. Anim. Indus. Circ. 67; Jour. Compar. Path and Ther., 19 (1906), No. 3, p. 191. See also U. S. Dept. Agr., Farmers' Bul. 237, p. 32.

During the past few years Prof. Bernard Bang, of Denmark, has carried on experiments in attempting to immunize cows, sheep, and goats against the disease. He has observed that aborting cows acquire a certain degree of immunity. His treatment produced abscesses and other symptoms of reaction, but considerable immunity resulted, and he hopes that this method of vaccination will ultimately give a means of controlling the disease.

PREVENTING LOSSES AT LAMBING TIME.[a]

During the lambing season of 1908 there was such a heavy loss of lambs in Virginia that W. J. Quick and A. P. Spencer, of the Virginia Experiment Station, made an investigation into the causes of this exceptional loss, with a view to suggesting means of reducing such losses. The facts recorded and the conclusions drawn from the investigation have a wide practical application.

It was found that "in 73 flocks visited 961 lambs were lost out of 5,252 dropped, or 19 per cent. In 65 flocks reported by letter, 1,478 lambs were lost out of 8,068 dropped, or 18 per cent. Figuring on this basis for the State as a whole, 70,147 lambs, valued at $350,375, were lost in Virginia during the lambing season of 1908.

"The estimated loss from natural and unpreventable causes was 14,029 lambs, valued at $70,145. The estimated loss from preventable causes was 56,118 lambs, valued at $280,590." The loss due to (1) cold and exposure was 40 per cent; (2) lack of milk, 31 per cent; (3) weakness, 9 per cent; (4) disease and accident, 3 per cent; (5) worrying by dogs, 1 per cent; (6) natural causes, 16 per cent.

Deaths from natural causes are classed as those for which no specific reason could be given. "In large flocks, even with the best of care, a small percentage of lambs will be lost. This is particularly true where the number and the conditions are such that individual ewes can not be separated immediately before lambing. It was apparent that some losses reported as natural were due to inattention."

While the conditions observed in this investigation were undoubtedly exceptional and the percentage of preventable loss given is probably unusually large, it is safe to say that as a rule the danger of loss at lambing time is sufficiently great to make it wise for sheep raisers generally to give more attention to protective measures. To this end Professors Quick and Spencer suggest that more attention should be given to the selection of vigorous breeding stock and to providing suitable protection against the weather. Expensive sheds are not considered necessary, but ewes and young lambs should have some protection from the north, east, and west winds. Sufficient shelter room should be provided to accommodate the entire flock without crowding. About 12 square feet of floor space should be allowed per sheep.

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[a] Compiled from Virginia Sta. Bul. 178.

There should be a warmer arrangement for ewes when they drop in bad weather and each ewe should be separated from the flock when she lambs. The location should be high and dry. The building should be liberally supplied with bedding to prevent dampness and insure cleanliness. A yard should be attached having a dog-proof fence.

In this the sheep should be confined every night as soon as the weather becomes unfavorable.

The most favorable time for lambs to drop, if intended for the June market, is apparently between February 15 to March 1.

Lambs dropped before this date suffer the hardships of the winter, and unless the ewes are very liberally fed do not get sufficient milk to make them grow rapidly. These lambs become more or less stunted and have not a plump and attractive appearance when marketed. There is also a greater possibility for loss with these lambs, and a much longer season for heavy feeding with the ewes, making an additional expense without a corresponding increase in weight, while lambs dropped after February 15 are less liable to loss from the most severe winter weather.

The great loss due to lack of milk can be largely prevented if the ewes for a month previous to lambing receive palatable foods rich in protein. A mixed grain ration of oats, corn, and bran is considered preferable to any of these grains fed alone, "but in case it is desired to feed any one alone, oats are most suitable. Corn alone is not very satisfactory, as it has a tendency to produce weakened lambs and a small milk flow." Clover, cowpea, or soy-bean hay, corn silage, turnips, sugar beets, and well-cured corn fodder may constitute the greater portion of the bulky ration. "It is very important to have sufficient feeding room, as the danger from crowding and pushing when ewes are heavy in lamb is very great and likely to cause some cases of abortion."

The flock should be closely watched at lambing time, for frequently a lamb can be saved if an attendant is present at the proper time.

The young ewes especially often require assistance in lambing. If a ewe does not drop her lamb within a reasonable length of time after labor pains are noticeable, there is a cause for the delay. Frequently a lamb is coming with its head bent back over its shoulder, or perhaps twins are coming together, or some other unnatural position. A little manipulation of the fetus will frequently straighten out the difficulty, thereby saving the life of the lamb, and not infrequently that of the ewe.

Some ewes refuse to own their lambs, and other ewes refuse to let the lambs nurse. Some ewes will accept strange lambs. When a ewe loses her lamb it is advisable to keep up her milk flow by milking, as she will frequently accept a strange lamb if it is given to her soon after lambing. Frequently a set of triplets or twins are dropped by a ewe and she has not sufficient milk to properly nourish all. If the ewe that has lost her own lamb is placed in a close pen and away from other sheep she will readily adopt one of the twins or triplets, thereby raising a good lamb instead of running idle and becoming too fat for breeding the following season. An orphan lamb may often be given a ewe that has just lost a lamb if the dead lamb is rubbed over the strange lamb while wet, or the skin of the dead lamb tied on the orphan, since the ewe's affections are directed by the odor of her lamb. * * *

While the loss from dogs is reported as comparatively small, the dog nuisance is nevertheless a great detriment to the sheep industry of Virginia. The direct loss from severe chasing and worrying is often not so great as the loss that follows. Breeding ewes that have been badly worried and frightened rarely, if ever, entirely recover. The result is usually weak and inferior lambs at the next lambing season, with some abortions and many abnormal presentations of the fetus. In fact, many breeders of registered sheep consider their breeding flock almost ruined after having been severely chased by dogs. Frequently a large number of ewes will not breed for some time after being chased and badly frightened.

The remedy for this nuisance is of course an efficient dog law rigidly enforced. In the absence of this legal protection resort may be had to dog-proof fences and like means of protection. At best, however, such fences are expensive. A dog-proof fence constructed at the experiment station at a cost of 65 cents per rod is described as follows (fig. 1):

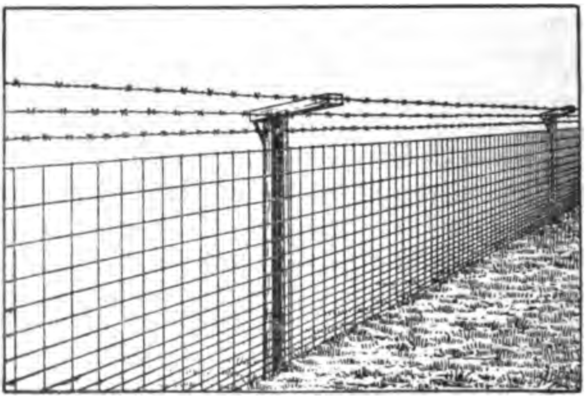

FIG. 1.—Dog-proof fence.

The woven-wire fence consists of 17 horizontal wires, the three lower wires 1½ inches apart, the width between wires gradually increasing to 5 inches at top. The vertical stays are 6 inches apart. The wire is fastened to posts set 25 feet apart, the bottom wire being 3 inches from the ground. One barbed wire is set midway between the bottom horizontal wire and the ground. One barbed wire is fastened to the posts 3 inches higher than the top wire. Two barbed wires are attached 8 inches apart to pieces of 2 by 6 scantling nailed to the posts above the wire with 20-penny nails. These pieces are set outward and upward with the posts.

Cost of materials.

		Cents.
Red cedar posts	each	12½
Woven-wire fence	per rod	37½
Four barbed wires	do	15
Total	do	65

The 2 by 4 scantling costs about $18 per thousand and adds about 1 cent per rod to cost of the fence.

Any other closely constructed fence would answer the same purpose.

WINTER LAMBS FOR THE PACIFIC COAST MARKET.[a]

Believing that there was a ready market for winter lambs in San Francisco at Easter time, as well as in the Eastern States, Professor True, of the Nevada Experiment Station, raised some crossbred Dorset-Merinos for this purpose.

In the spring of 1905 thirty half-blood Dorset ewes were ready for the experiment. They were turned in with the ram the middle of July, with the result that lambs were born from December 10 to February 21. Ten ewes lambed in December, thirteen in January, and seven in February.

It will be remembered that the month of December and a part of January were characterized by unusually stormy, wet weather. Half of the lambs came during this time of snow and mud, and the only shelter they had was that furnished by a shed boarded up for not more than 3 feet above the ground. In spite of these adverse conditions, the lambs made a very satisfactory gain of over four pounds a week. The ewes were fed alfalfa hay, chopped roots, and grain consisting of a mixture of barley and bran. The lambs were also fed grain separately.

The attempt to find a market for the lambs when grown resulted very satisfactorily. To begin with, Reno and Goldfield butchers and the Palace Hotel of San Francisco offered 20 cents a pound, dressed weight, for the lambs. After receiving the first shipment of lambs, however, the Palace Hotel wired an order for more at 35 cents a pound on board the cars at Reno, and took all that we could supply at that price.

From this experience it is apparent that at least there is a limited market in San Francisco for first-class lambs throughout the winter season.

FEEDING WORK HORSES.[b]

The subject of an efficient and economical feed for work horses is one that is of interest not only to all farmers but to a large number of people who live in towns and cities. The grocer and butcher as well as the liveryman and the head of an express or transfer company are vitally interested in knowing what ration will give the greatest efficiency at the least cost.

There is a widespread belief among horse owners that no grain is equal to oats as an efficient feed for horses and that no matter how high the price of oats, no other grain can be used as a substitute for them.

In order to test the accuracy of this belief, B. E. Carmichael, of the Ohio Station, began in the spring of 1907 an extensive series of experiments to test the relative value and efficiency of oats and corn as a grain ration for work horses.

With this in view, three teams of grade Percheron geldings were taken; these horses were used for general farm and team work on the station farm. The horses in each team were about the same age; one was fed on oats and the other on corn. The plan was to feed as much ear corn by weight as oats. All the horses received as much mixed clover and timothy hay as they would eat. The experiment reported was continued forty-eight weeks. The variations in weight of the corn-fed horses were practically the same as those of the horses receiving oats; nor was it noticed that there was any difference in spirit or endurance between the mates of each team.

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[a] Compiled from Nevada Sta. Bul. 63. [b] Compiled from Ohio Sta. Bul. 195.

In regard to the comparative cost of the feeds it is stated that—

> Under the market conditions that prevailed during the experiment the saving from the use of corn was very marked—approximately 10 cents per day for each horse for the entire forty-eight weeks. Market conditions should always be borne in mind, as there may be times during which oats would be cheaper than corn, and they should, of course, be used whenever cheaper.

Some preliminary conclusions drawn from the first year's experiment are as follows:

> While the work reported in this bulletin has not been conducted for a sufficient length of time nor with enough animals to justify any very comprehensive statements, yet it seems that some facts have been pretty well established. The work is being continued, and it is hoped that the cumulative effects, if any result, of the long-continued use of grain rations made up exclusively of corn and of oats may be determined. The following statements, based upon the work done thus far, seem to be warranted by the data presented heretofore. It must be understood that the horses were mature geldings and that mixed clover and timothy hay was fed.
>
> The corn-fed horses endured hard work during hot weather as well as did the oats-fed horses.
>
> The use of corn to the exclusion of other grain for a period of forty-eight weeks was not detrimental to the health of work horses.
>
> The use of corn for work horses did not induce laziness and lack of endurance. Neither did the use of oats induce increased spirit and endurance.
>
> When mixed (clover and timothy) hay was fed to mature geldings at general farm work, ear corn was practically as efficient, pound for pound, as oats.
>
> On the basis of the results of this experiment and statistical records of farm values of grains, corn has, since 1866, been cheaper than oats as a grain feed for work horses.

It is planned to continue this work for a number of years and thus eliminate any variations that may be due to individual horses.

During the second year the horses received reversed rations, that is, the corn-fed horses received oats and vice versa. It should also be noted that the variation in weight during twelve weeks, when the corn-fed horses received shelled corn instead of ear corn, seems to indicate that the shelled corn was not so thoroughly masticated and therefore less efficient.

Station work with various rations for horses has been reported in a previous bulletin of this series.[a]

COLONY HOUSES FOR POULTRY.[b]

The main requirements of a good poultry house are good ventilation and protection from storms and cold winds. Hens will not lay when weather conditions prevent them from scratching and exercising. Many poultry houses have failed because the variations in night and day temperatures were too great. At many of the experiment stations it has been found that open-front houses are more successful than houses with glass windows.

---

[a] U. S. Dept. Agr., Farmers' Bul. 316, p. 22.

[b] Compiled from Arkansas Sta. Bul. 99; Oregon Sta. Circ. 4; Utah Sta. Bul. 102.

J. Dryden and A. G. Lunn, in a circular of the Oregon Station, state that—

> Ventilation can best be furnished by leaving one end of the house open or covered with burlap or canvas, using no glass windows unless necessary for light. The idea of building a warm house should be abandoned. It is shelter that is needed. The house should be built in such a way that the fowls will not roost near the open front where they would be exposed to winds; nor should it face the prevailing winds. A long house is more expensive to build, for a given capacity, than one more nearly square. A long, narrow house is also a cold house, having more exposed surface for a given capacity than a square house.
>
> The size of house necessary for a certain flock will vary in different sections. Where there is little or no snow and where the fowls can be outdoors every day in the year, two square feet of floor space per fowl will be ample. Where the climate is such that the fowls will seek shelter part of the year, rather than go outdoors on the range, considerably more space should be provided, say four to five square feet per fowl. The idea should be not to crowd them so much that their activity will be interfered with. Whether the shelter is provided by enlarging the house or providing cheap scratching sheds is immaterial. Two square feet per fowl, or even less, is ample for roosting quarters.

W. S. Jacobs, of the Arkansas Station, states that—

> Roosts should be made low or near the ground—not higher than 2 feet. There are several reasons for this. Fowls of the heavier breed can not fly high, and those of the lighter breeds frequently injure the soles of their feet in jumping from high perches. Roosts should be made all the same heights; for if they are made some higher than others the birds will all flock to the highest ones and crowd, which is undesirable.
>
> When dropping boards are used they should be low down, to permit of easy cleaning. They should be made of matched lumber and be 20 inches wide for one perch and 3 feet wide for two perches, the first perch placed at least 10 inches from the wall. A good roost may be made from material 2 by 2 inches, then slightly rounded on the edges.

According to Dryden and Lunn—

> Poultry keeping is most successful where the colony system prevails. The colony system means the housing of fowls in small houses, preferably portable, where the fowls have free range. The chief advantage is that the fowls are more active or busier than when confined in yards; second, there is less danger from outbreaks of disease, as it is possible to keep the houses on clean ground by moving them occasionally; and third, the fowls require less feeding and care, as they pick up considerable food on the range. Another advantage of this system is that the fowls will rid the farm of many injurious insects, such as grasshoppers. Then, the colony system will fit in with crop rotations and for part of the year the fowls will live on the stubble fields.

Figure 2 represents a successful colony house with a cloth front, which was used at the Utah Experiment Station. The trap nests in the rear of the building can be opened from the outside (fig. 3). Fig.

4 is an illustration of a Rhode Island closed-front house. A good size to build a colony house is 7 by 12, which is large enough to accommodate 30 to 40 fowls, yet is not too heavy to be drawn by a pair of horses when it is desired to move it to a new location. Below are given the details for constructing a colony house (fig. 5) of this size, as recommended by the Oregon Experiment Station.

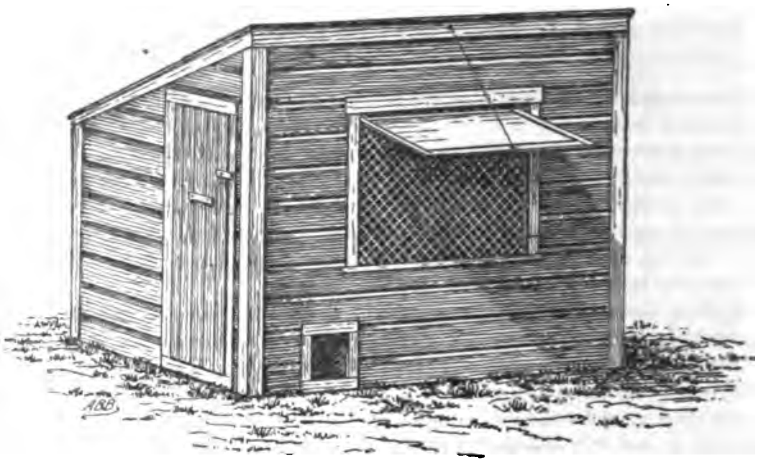

FIG. 2.—Utah Station colony house with cloth window.

Construction of the colony house.—The runners are made of 3-inch by 6-inch by 14-foot rough material and act as side sills for the house. They should be beveled at ends, in order to slide easily. The cross sills are 3 inches by 4 inches by 7 feet. They are set 2 inches into the runners and 12 inches from the ends, and fastened with $\frac{1}{2}$-inch bolts. When the siding is put on vertically there is no studding used. The plates are 2 inches by 3 inches by 12 feet, halved at each end. To the plates are nailed the 1-inch by 12-inch by 5-foot side boards, and these are battened with 1-inch by

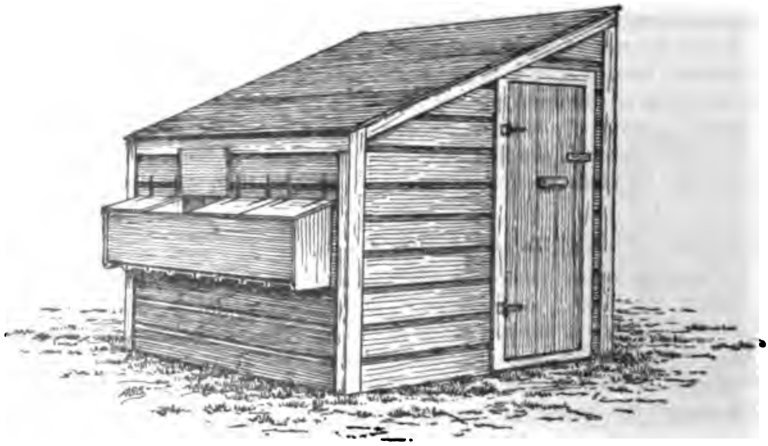

FIG. 3.—Utah Station colony house showing trap nests opening at the rear.

3-inch. The siding is nailed flush with the top of plate and laps 3 inches on runners. The roof is one-third pitch, or 2 feet 4 inches at peak from top line of plates. There are five pairs of rafters, cut with a 1-inch plumb cut at plate. The roof boards are 1-inch by 3-inch material, set 3 inches apart. The roof is shingled and laid 5 inches to the weather. The front is covered with 1-inch mesh wire. The cornice is made of 1-inch by 8-inch boards and projects 5 inches outside of walls. The frieze board, 1 inch by 4 inches, is nailed up tight against the cornice. The door is 2 feet by 6 feet and made from 1-inch by 3-inch material. The nest platform is 2 feet from the ground. It is nailed to a cleat on the side of the house and braced from top of runner. The platform is 22 inches by 5 feet. The nests are made of 5-gallon oil cans, the top and part of front

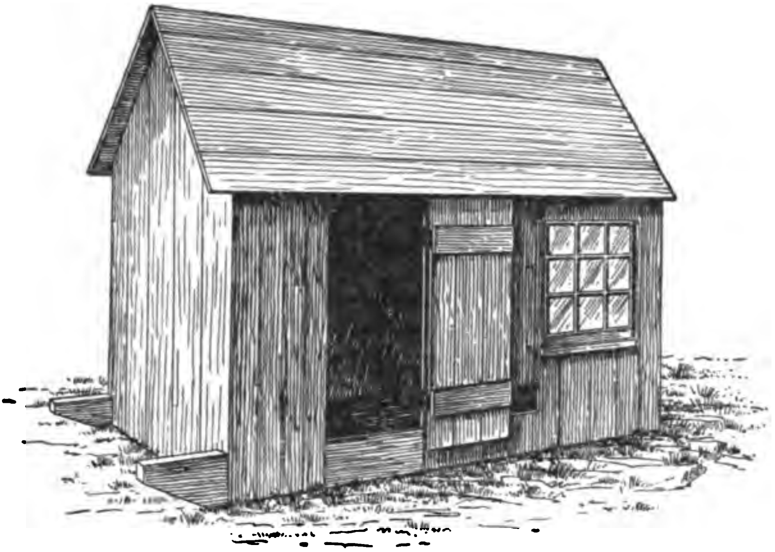

FIG. 4.—A Rhode Island closed-front colony house.

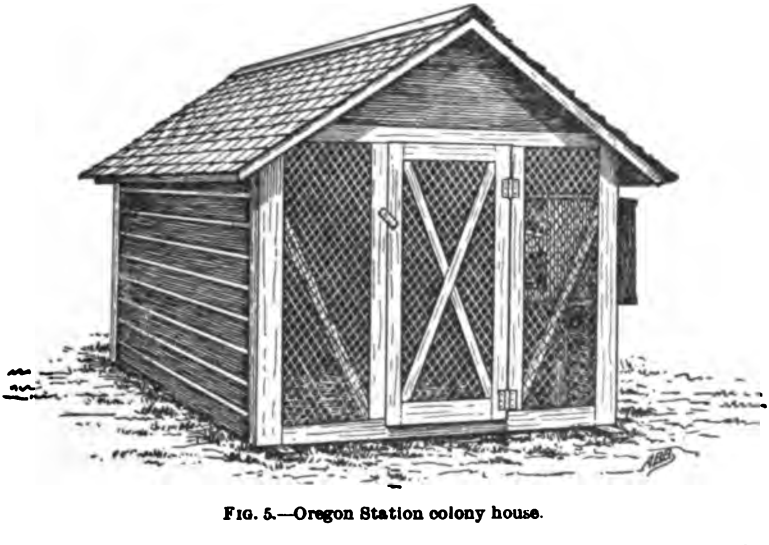

FIG. 5.—Oregon Station colony house.

With the strong flours the proportion 150 grams flour, 12 grams butter, and 8 grams baking powder gave the best results. As regards oven temperature, 450° F. proved most satisfactory. The loss in weight in baking the biscuits ranged from 14 to 22 per cent of the initial weight. With the soft flours and the blend much the same range of loss in weight in baking was noted.

As regards the relative value of the different sorts of flour for the purpose studied, the author concludes that "other things being equal, soft wheat flours make tenderer milk biscuits than strong wheat flour."

Given a strong wheat flour dough and a soft wheat flour dough of equal slackness and suitable for milk biscuits, the soft wheat flour dough is the easier to handle.

At the present prices of the different flours the strong wheat flour biscuits cost more than soft wheat flour biscuits.

It is possible that a larger proportion of fat used with the strong wheat flour would yield biscuits of tenderness equal to those of soft wheat flour, but the cost of fat makes that method of improvement a disadvantage.

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FARMERS' BULLETIN 375.

CARE OF FOOD IN THE HOME.

BY

Mrs. MARY HINMAN ABEL.

PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS
A. C. TRUE, Director.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., April 14, 1909.

Sir: I have the honor to transmit herewith, and recommend for publication as a Farmers' Bulletin, an article on household methods of handling and storing food, by Mrs. Mary Hinman Abel.

In this bulletin Mrs. Abel has summarized the results of experiments and tests specially undertaken for it, as well as experience obtained in the practical handling of such problems. The information thus collected has been supplemented by general data gathered from the publications of the agricultural experiment stations, agricultural colleges, reports of state boards of health, government documents, and other sources of information.

The questions considered have to do with the economical use in the home of the products of the farm, dairy, and garden, and also with the subject of household hygiene. These are subjects of interest to the housekeeper in both rural regions and town, and the bulletin has been prepared with a view to meeting the numerous requests received at the Department of Agriculture for information along such lines.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction.. 7
Yeasts, molds, and bacteria, and the spoiling of food........................ 7
  The nature of yeasts, molds, and bacteria........................ 7
  Yeasts and their utilization........................ 8
  Molds and their prevention........................ 9
  Bacteria and how to control them........................ 10
  Ptomaine poisoning........................ 11
  Disease "germs" and polluted water........................ 12
  The necessity of caution in the use of raw foods........................ 13
Flies and food........................ 14
Dust in its relation to food........................ 17
Pet animals in the kitchen........................ 18
The food supply........................ 19
  Clean shops and markets a necessity........................ 20
  Sanitation of bakeries........................ 21
  The quality of meats........................ 23
  The true price of meats........................ 23
  Poultry........................ 23
  Fish........................ 24
  Vegetables........................ 24
The storage of food........................ 26
  Commercial cold storage........................ 26
  The storeroom in the home........................ 27
  Hot-weather storage........................ 28
  Ice machine........................ 29
  Ice chests........................ 29
  Care of ice chests........................ 29
  Water for cooling food........................ 30
  Winter storage of food........................ 31
  A window storage box........................ 31
The keeping of vegetables, fruits, and meats........................ 33
Storage of groceries, meats, cooked food, and canned goods........................ 34
  Bread and other cooked foods........................ 35
  Canned fruits and other canned goods........................ 36
  Labeling foods in packages and cans........................ 37
Care and utilization of fats........................ 37
Handling of food and utensils in the kitchen........................ 38
  Meats........................ 38
  Poultry........................ 39
  Washing vegetables........................ 39
  Washing fruits........................ 40
  Washing eggs........................ 41
  Dishwashing........................ 41
  Care of the water cooler........................ 42
  Personal cleanliness in the kitchen........................ 43
  Use of paper in the kitchen........................ 44
Importance of good house plans and home conveniences........................ 44
Cleanliness in public eating places........................ 45

ILLUSTRATIONS.

Page.
FIG. 1. Cellar window constructed to secure ventilation........................ 28
2. Window box for storage of food.. 32

CARE OF FOOD IN THE HOME.

INTRODUCTION.

The woman who presides over a household should consider as one of her most important functions the purchase of food and its storage preliminary to use in the kitchen. Should she be living on a farm she will buy less in amount than the woman who lives in the town or city, but, on the other hand, the storage of food will demand more of her attention. In both cases, if intelligence and care are lacking, financial loss will ensue and the family table will be less attractive and wholesome than it should be.

Most families have traditions and well-established customs to guide them in the handling and storing of foods, but since the customs of one family may differ widely from those of another, it is well to examine and compare them in order to select the best. Scientific investigation has also thrown light on many of the processes concerned and the result of such labors should be at the service of the householder. The health and efficiency of the family is the chief object of her care, and it is an end well worth the effort.

YEASTS, MOLDS, AND BACTERIA, AND THE SPOILING OF FOOD.

In the buying, storing, and handling of food it is most important that we realize the causes of what is called the "spoiling" of food. This knowledge is comparatively recent.

THE NATURE OF YEASTS, MOLDS, AND BACTERIA.

Countless numbers of tiny living things called micro-organisms, a word meaning simply "small living things," are everywhere found which will grow in the food man has prepared for his own use and cause it to spoil. Indeed, the kind of food required by man and animals seems to be that which is also best suited to these microscopic plants.

It is this very demand for highly organized food which brings them into such close relation to all problems that concern the food of man. These microscopic plants flourish in the kitchen, storeroom, ice box, milk room, and cellar. If the conditions are favorable they reproduce themselves with incredible rapidity, one bacterium in the course of a day producing a million more minute plants like itself. The bulk of these minute forms of life are harmless, at least under usual conditions; some are useful, like those which ripen milk; and many are harmful, since they cause waste or may be, what is much more serious, a direct cause of disease.

Molds, yeasts, and bacteria may be found in the cleanest room, but they exist in far greater numbers in dirty quarters, where, for instance, crumbs of food have been allowed to decay and dust to accumulate. Not only do the micro-organisms appropriate our food, with the result that the food sours, rots, or putrefies, but they sometimes, in addition, leave behind disagreeable consequences like the musty and moldy odor and flavor of some spoiled foods, or the substances called ptomaines, which are sometimes poisonous. The housekeeper's success in preserving food from deterioration depends very largely on her ability to reduce the number of these unbidden guests to the lowest possible limit.

The science of bacteriology has given us a new meaning for the scrubbing, airing, and sunning that for many generations good housekeepers have successfully practiced; it shows us that the storing and handling of foods are essentially bacteriological questions, and on that account some knowledge of the nature of these microscopic plants is here in order.

YEASTS AND THEIR UTILIZATION.

Not until millions of yeast cells are massed together do they become visible to the eye as in the compressed yeast cake. Yeast plants are practically everywhere and are of many varieties, some being called "wild yeasts," in distinction from those we have learned to cultivate for the making of bread and brewing of beer, and the fermentation of wine and cider. The old-fashioned method of making "milk-rising" or "salt-rising" bread depended on wild yeast falling into the dough and causing the bread to rise, a method not always successful, because other organisms, the bacteria, also had a chance at the dough and sometimes got the better of the yeast in the struggle for food, and the result of their life in the dough was sour or bitter bread.

Even when we are able to utilize the life processes of the yeast plant, its good offices are paid for with a certain amount of food material; thus, when introduced into the bread dough it breaks up part of the sugar present into alcohol and carbonic-acid gas, and the gas becomes tangled and stretches out in the glutenous mass, making the porous loaf which at the right moment is stiffened by the heat of the oven.

In the same way the wild yeast attacks the sugar in the stewed fruit that has stood exposed on a warm day, or the jelly left uncovered, or sometimes even when apparently covered, only in these cases the gas evolved serves no useful purpose and the fermentation ruins the taste of the food.

Yeasts grow best at a temperature of 70 to 90° F.; therefore, food that is to be protected from their action must be kept well below this point.

MOLDS AND THEIR PREVENTION.

The appearance of mold as growing on bread, cheese, and other foods is familiar to every housewife; mildew on cloth is a less commonly recognized form of mold.

The spores (i. e., the minute reproductive bodies) of the different varieties of mold are everywhere present, and they need only warmth and moisture to enable them to grow on many kinds of food. These organisms are always at work in damp cellars and in dark and damp corners of rooms; they are borne on the feet of insects, they are on the skins of all fruits, and in the dust flying in the air. They are not fond of light and they require no great abundance of air, flourishing best in foods that are piled close together, leaving small undisturbed air spaces and moisture. They always start on the surface and throw their thread-like filaments down into the substance below. Take, for example, a fine ripe apple and closely examine the skin. If it is in good condition and attractive it is almost certain that the flesh is protected in the natural way by an unbroken skin which resists the entrance of molds and other micro-organisms. If, however, the apple has begun to spoil, it is almost certain that the skin has been broken.

When fruits touch each other, the point of contact is likely to be moister than the rest of the fruit, and for this and other reasons it is a favorite place for the starting of mold or other growth. If the skin is perfectly firm and we rub it with a clean cloth to dry it and to remove as many as possible of the mold germs, then wrap the apple in soft paper and put it in a cold place, precautions have been taken which should hinder or prevent decay. If, however, the fruit is kept in a warm and damp place, and touching other fruits, its decay is certain. In dealing with all varieties of microscopic life we have learned that to prevent them from getting a start is the all-important thing. The growth, once begun, is difficult to arrest.

The first requisite is absolute cleanliness in the storage place. This is not to be attained by the use of soap and water alone. Fresh air, sunshine, and whitewash are important aids. Shelves should be washed clean and then dried; but the undue use of water should be avoided, as moisture is one of the chief requisites of growth. A cellar may be kept dry by placing in it dishes of unslaked lime, which takes up the moisture with avidity. When the lime crumbles apart, losing entirely its crystalline character, it has become "slaked," will take up no more water, and must be renewed.

The growth of most molds is retarded by light, ventilation, and low temperature. Light and ventilation are important. The right degree of cold for each different product has been studied experimentally, and a knowledge of low temperature in relation to the growth of bacteria and fungi forms the basis of the cold-storage industry.

BACTERIA AND HOW TO CONTROL THEM.

From the standpoint of household sanitation bacteria are by far the most important of the three groups of micro-organisms under consideration. They are many times smaller than the yeasts, and their power of reproduction is almost unlimited. They require at least 25 per cent of moisture in which to live and multiply, and they prefer darkness to light, and while as a class they grow best at a comparatively high temperature, 80 to 95° F., most of them are killed by an exposure to 150–160° F. of moist heat. A repeated application of boiling temperature is necessary, however, to kill the spores which certain kinds produce.

Bacteria are very widely distributed; the soil teems with them; they are in the air, in water, and in all food exposed to dust and air, milk being a favorite habitat. The flesh of healthy living animals is free from them, but when slaughtered and marketed the surface is almost certain to acquire bacteria, like all things which are exposed to air and dust. They are inside the human body, often performing important functions, as in intestinal digestion. In short, wherever organic material is exposed to their inroads there they are found.

It is said that the numbers of bacteria are in direct relation to density of population. We can not get away from them without going into the highest mountains or to the polar regions; but we can protect our food supply from their undue growth by reversing all the conditions that they require for their development.

It is of primary importance that bacteria be prevented from getting their start. Hence, only such foods should be bought as are in the freshest and best possible condition. Since succulent fruits, milk, raw meat, and meat products are especially subject to bacterial action, they must be given unusual attention. They should be consumed as soon as possible after purchase or subjected to the following conditions: Utensils that come in contact with them must be thoroughly scalded, or better, boiled. The hands and clothing of the worker must be kept clean and every effort made to avoid contact with dirt. Of cooked foods, moist vegetables, cooked fruits, moist made dishes like meat pies and similar dishes are particularly liable to "spoil" or "sour," and the importance of clean utensils, of keeping the foods protected from dust, etc., can not be too often pointed out.

The temperature at which food is kept should be reduced to that best suited to it, which is usually as near the freezing point as possible. Highly putrescible food, as meat, is thus kept for months in cold storage, and a good ice box will keep such food for days in perfect condition. Cool clean storage is as important for many cooked foods as for raw.

Since the water content of food must be above 25 per cent before bacterial life is possible in it, we may preserve food by drying it. This method, often in combination with salting and smoking, is applied to fish, meat, vegetables, and fruit.

By exposing food to 150–160° F. of heat for half an hour all varieties of bacteria would be killed except a few that are very resistant to heat. In the case of spore-forming bacteria the spores would in certain cases resist this degree of heat. The pasteurization of milk offers a familiar example of a food that is kept from spoiling by this method.

After thorough boiling food may be sealed from the outer air by the well-known method of canning.

Most varieties of bacteria are killed in a few hours by direct sunshine, but it must be direct. The recesses of a dark room are little affected by what sunshine may filter into its depths. Contents of storerooms should now and then be sunned, and such rooms should be regularly aired.

We may often make use of substances that inhibit bacterial growth. These tiny organisms can not live in a very heavy sugar solution, a fact made use of in preserving fruits. Vinegar, spices, salt, and wood smoke have a like effect, and their use is familiar in pickled and spiced vegetables and fruits and in salted and smoked meats.

PTOMAINE POISONING.

In some foods bacteria in the early stages of their action leave no disagreeable or unhealthful effects, so far as yet proved. Meat is in some measure ripened by bacterial action, and the "gamey" taste given meat by "hanging" comes in part from the same cause, though in both cases the changes are chiefly due to the action of ferments normally present.

It is not easy to draw the line between the harmless ripening processes and the bacterial changes classed as decay, but if the bacteria are allowed to grow without hindrance the time comes when the food, either animal or vegetable, attacked by bacteria breaks up into a loathsome mass.

The food may become dangerous even before it shows outward signs of decomposition, for the bacteria may, as they feed upon the proteids, give off substances known as ptomaines, hardly to be recognized without laboratory apparatus, but some of which are very poisonous to man. Certain apparently mysterious cases of illness have been traced to such causes, and milk, fish, meat, cheese, baked beans, ice cream, and other foods have all been found responsible for "food poisoning." It is no uncommon thing to hear that a large number of the persons attending a banquet were taken violently ill within a few hours after, all with very similar symptoms. In some cases the illness has been of brief duration, in others it has continued for days, or even resulted in death. In one instance the offending food may have been lobster salad, in another, cold-storage chicken, in still another, ice cream. These severe cases of wholesale poisoning generally occur in the summer and after a very heated term. Doubtless many milder cases, called summer complaint, are due to the same cause. This sort of poisoning is not a true bacterial disease; that is, it is not due, as is typhoid fever, to the growth of an organism in the body, but the illness results from the introduction into the system of poisonous substances already formed in the food by the bacteria.

It is not known under what conditions these peculiar poisons are developed in foods; we know only that they are the result of bacterial action not so advanced as to give warning to the senses. It is a safe rule to eat very sparingly of foods which are liable to such changes in hot weather, and especially where the methods of preparation are not known or where the serving of a large number of people at the same time brings an undue strain on the culinary forces, in which case material is certain to be served which has been prepared a considerable time in advance and not properly cooled and stored.

DISEASE "GERMS" AND POLLUTED WATER.

The so-called "germs" of typhoid fever, diphtheria, and tuberculosis are bacteria, and as they may be conveyed by means of water or food this danger is a very real and serious one.

As a proof that contaminated water is the direct or indirect source of typhoid-fever infection it may be mentioned that the statistics of 10 large European cities whose water supply is drawn from pure mountain lakes and streams showed in 1905 a death rate very much lower than that of a large number of American cities whose average death rate from typhoid fever was 34 per 100,000 inhabitants.[a]

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[a] Jour. New England Waterworkers' Assoc., 19 (1905), No. 4, p. 575.

The germs of typhoid fever, like those of cholera, are voided in the feces and urine of the patient. Because of carelessness or ignorance in the disposal of these excreta they find their way into surface drainage, reach brooks and streams, and defile wells. Such infected water used as a beverage may readily cause typhoid. By means of milk cans washed in such water, or by the hands and clothing of persons who have nursed typhoid patients, the germs are planted in milk, and in this nutritive medium they develop with wonderful rapidity, so that milk becomes, next to water, the great carrier of typhoid. It is also known to have carried diphtheria and scarlet fever and it has well been called the most valuable and the most dangerous food. The relation of flies and dust to typhoid and other diseases is discussed later (see pp. 14 and 17).

For protection from a polluted water and milk supply we must look chiefly to sanitary laws and their rigid enforcement. In such laws the housekeeper who is seeking to guard the health of her family has, or should have, the most lively interest. She should understand them herself, report any cases of disobedience that may come to her notice, and be willing to work for the passage of better laws if they are needed.

If the water supply is not known to be well guarded from pollution the existence of a disease like typhoid fever in any locality requires that the greatest precautions must be taken in every house. The drinking water must be boiled to destroy any disease-producing bacteria possibly contained in it, and this boiled water must be used for cleaning the teeth, for washing such vegetables and fruits as are consumed raw, and also in rinsing dishes and cooking utensils.

The tubercle bacillus, the cause of tuberculosis, should also be guarded against, though it is not likely to be carried by city water. Food may become infected with it from contact with a person suffering from the disease, and it is not unreasonable to forbid any such to aid in preparing meals. It is also a reasonable measure to prohibit the sale of milk from a farm where the disease is known to exist.

THE NECESSITY OF CAUTION IN THE USE OF RAW FOODS.

The numerous cautions suggested in this bulletin may seem unnecessary, but a few facts will show that they are not extreme.

In older civilizations, where the soil has been exhausted and needs constant manuring, cooked fruit and vegetables rather than raw are much more the rule than with us. In densely peopled China, where night soil is used to fertilize the land, the eating of raw vegetables is said to be very rare. It is easy to see why such foods uncooked might be very dangerous. Although such methods are not followed to any great extent in the United States, raw fruits and vegetables may be a menace to health. Methods of washing fruits and vegetables are discussed in another section.

A Russian authority, Professor Metchnikoff,[a] because of the possible presence of disease micro-organisms and minute animal pests, as intestinal worms, strongly advises against the eating of any raw food whatever, even if it has been washed in boiled water. Although this view may be considered extreme for American conditions, it shows what care must be taken in the purchase and the cleaning of food that is to be consumed raw.

Kitchen methods in many of their details fail to meet the requirements of sanitary science. The cook is not trained in bacteriology; she does not know what cleanliness means from the laboratory point of view. The old-fashioned hatred of dirt for its own loathsome sake is the best substitute for this knowledge, but it is not enough. For instance, boiling has long been known to kill whatever was the cause of "spoiling" of food. However, most housekeepers did not "boil out" the milk pans, etc., but simply scalded them. "Scalding" is an indefinite term; if boiling hot water is used, and enough of it, scalding would doubtless be effective, but too often when the facts in the case are not thoroughly understood such a process is carelessly carried out and the desired end is not accomplished. When in such cases the milk spoils very quickly it is often attributed to the weather or to bad luck. The housekeeper who understands the causes of spoiling, and who knows that the microscopic plants responsible for it may be destroyed by a sufficient degree of heat applied for the proper time, is much more likely to be successful than one who works by rule of thumb. Here, as in so many other household problems, knowledge is essential. How is the ignorant cook to know that what lurks unseen in crack or seam may bring to naught all her precautions? The homely old dictum that the only way to conquer dirt is by "eternally keeping at it" is as true as ever it was, but as we have come to realize more and more the insidiousness and omnipresence of the enemy to health, and that in the form of bacteria it consorts with dirt, we realize also that every housekeeper and houseworker must be made to understand something about the microscopic forms of life which are harmful, and how to apply all the weapons which modern science has discovered for their destruction.

FLIES AND FOOD.

The intelligent housekeeper of this generation has at her command a wealth of scientific knowledge that may be applied to the solution of problems in home sanitation. Of great value are the means which have been devised, thanks to the work of the Bureau of Entomology of this Department, the agricultural experiment stations, the state boards of health, and investigators in many universities and other institutions, to prevent the spread of disease by insects and other forms of animal life. In the nature of things the importance of this matter was not recognized until it had been shown with certainty that such animal life played an important part in the transmission of disease. Two varieties of mosquitoes are generally conceded to be absolutely necessary to the transmission, respectively, of malaria and of yellow fever, since the organism that causes these diseases must first undergo a complicated series of changes in the body of the insect before it is capable of producing a new case. Thus, the mosquito bites a yellow-fever patient and takes the micro-organism into its body, and there for some twelve days it is developed to the stage of maturity, after which time and not before the mosquito can convey the disease by biting. In such cases the insect is called an "intermediary host." Both diseases are now successfully fought by exterminating the breeding places of the mosquito and by the screening of dwellings.

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[a] The New Hygiene. New York, 1907.

Insects play a still larger part as mechanical carriers of disease germs, the greatest menace of all in our daily life being the common house fly, known to scientists as the *Musça domestica.* It is not a biter, like the horsefly and some other flies, or like the mosquito, but it has its own way of carrying infection. It breeds in manure and it feeds on it; it feeds on the sputum of diseased throats and lungs, on typhoid dejecta, and refuse of all kinds, and by means of its hairy feet and legs it carries about and distributes particles of these vile feasts, which frequently contain living germs capable of producing a new case of disease. In still another way does the fly spread disease—disease germs taken into its body in food are known to remain alive in the intestines and also for days after they are ejected in the "specks," i. e., in the fly excrement. By recent experiments with animals this has been proved true of both the tuberculosis and the typhoid bacillus, the germs in the "speck" having actually given the disease from nine to fifteen days after it was voided by the fly. Also the eggs of worms that it draws into its body with water that it drinks are known to remain alive and to hatch after being ejected.

The case against flies is well proved, and yet they are allowed to infect the joint of meat exposed for sale by the butcher, the bread and sweetmeats of the confectioner's counter, berries and other fruit, the edge of the milk pail, the kitchen table and utensils, and the food of our table. They were shown to be the principal carrier of the typhoid fever which attacked 20 per cent of the United States soldiers in the Cuban war and furnished 86 per cent of the deaths.

As the report[a] states, "Flies undoubtedly served as carriers of infection. * * * It is probable that the infection was [also] disseminated to some extent through the air in the form of dust." Furthermore, it is pointed out that the men undoubtedly spread the disease by means of infected material conveyed on their persons and clothing. Water was not regarded as an important factor in the spread of typhoid fever in the national encampment of 1898. Since that time so many well-proved cases have been traced to the fly that Dr. L. O. Howard[b] recommends that the name "typhoid fly" should be generally adopted, in order to call attention to the danger of allowing this insect access to our dwellings.

In the monthly report of one of our state boards of health[c] is graphically described a scene familiar to many of us:

> In front of a grocery boxes of blackberries were exposed for sale. They were slightly gray; dust and swarms of flies were present. On the sidewalk, within 6 feet of the berries, some poor diseased mortal had spat, and this sputum was circled with flies. A moment's observation showed that they flew back and forth, not only between the berries and the sputum, but also between the berries and the gutter filth and street manure. But, most wonderful, people purchased those nasty berries and ate them raw.

It was found later that much diarrhea existed in the neighborhood, caused possibly by bacteria transmitted by these very flies.

We are far too tolerant of the presence of this filthy and dangerous insect. Its breeding grounds should be the first point of attack. The Bureau of Entomology of the Department of Agriculture has given a great deal of attention to the matter, and the publications of the Bureau should be consulted for full data on the subject. A summary may be found in an earlier bulletin of this series.[d] On the authority of this Bureau it is stated that at least 95 per cent of the town and city flies are bred in heaps of horse manure left in roads, fields, and stables. The remedy proposed is stricter enforcement of the laws governing the cleaning of streets, and the covering of all manure pits in town and country, with occasional spraying with crude petroleum. The manure pile and the barnyard are the fly-breeding ground of the farm.

To urge the housewife to work for public measures to insure such sanitary reforms is not asking her to go too far afield. In her own house she will endeavor by the use of screens and fly paper and similar means to protect herself from this dangerous insect. But she will wage an unequal battle unless the root of the evil is attacked, and this can only be done by removing manure and other refuse that form the breeding places of the fly. This question is considered in the government documents referred to (p. 16).

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[a] Abstract of Report on the Origin and Spread of Typhoid Fever in United States Military Camps during the Spanish War of 1898. Washington, 1900.

[b] U. S. Dept. Agr., Bur. Ent. Bul. 78.

[c] Mo. Bul. Ind. Bd. Health, 10 (1908), p. 64.

[d] U. S. Dept. Agr., Farmers' Bul. 155.

Briefly, the manure should be collected in pits where it may be kept covered, or where it may be treated with kerosene oil or some other material which kills the eggs and larvæ. It is of still greater importance that flies should never have access to human excreta.

DUST IN ITS RELATION TO FOOD.

What is the composition of dust? It has been described as a little of everything. In the paved streets of cities and towns earthy particles from the soil are always present. While street dust in the country is largely made up of the powdered earth of the road mixed with finely ground manure, in cities its lighter particles are principally dried horse manure with more or less of dried powdered sputum; facts sufficiently disgusting to give us a hearty aversion to dust as an accidental accompaniment to any article of food. The dust of rooms contains earthy particles, minute fragments of clothing fiber, bits of abraded skin, and pieces worn away from walls, floor, and furniture, also mold spores, bacteria, and street dust in greater or less quantity, according to the location.

Every precaution should be taken if there is illness in a house, particularly tuberculosis or other infectious or contagious disease, to prevent the micro-organisms which cause the disease from getting into the air and dust. Dr. Michael Prudden[a] gives the results of attempts to count the bacteria in the dust of New York streets. A culture plate of 3½ inches in diameter was exposed for five minutes with the following results: Central Park, near street, collected 499 bacteria; Union Square, collected 214 bacteria; large dry goods store, collected 199 bacteria; street while being swept, collected 5,810 bacteria.

The daily examination of the milk of a certain model dairy revealed suddenly a great increase in the bacterial count. The physician and the bacteriologist examined the premises and watched every process in a vain effort to determine the cause until it was noticed that the milk pails were put to sun where the dust blew on them. This cause removed, the bacterial count returned to normal.

These air and dust bacteria are not necessarily harmful, but where large numbers are present there are likely to be among them those which produce disease. A number of cases of illness are on record directly traceable to fruit, but it is difficult to determine whether in such cases infection has come through dust settling on the food or through direct contact of the fruit with infected human beings.

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[a] Dust and Its Dangers, p. 26.

Better market inspection is needed, better protection for food from dust both in transit and when on sale, and a more rigid carrying out of existing laws, but, above all, a demand for clean food on the part of the buyer.

Precautions should also be taken against dust after the food is delivered at the house. In modern dairying much stress is laid on the fact that sweeping the stable before milking fills the air with bacteria which are likely to infect the newly drawn milk. The same danger arises if food and dishes are left exposed in kitchen or pantry during sweeping. Tests have been made to determine how great this danger really is in ordinary household practice, and it has been found not only that molds, yeasts, and bacteria are much more abundant in the air during sweeping, but that those stirred up by the sweeping do not settle back again for several hours afterward. Evidently, then, it is not sufficient to cover food and dishes during the actual sweeping; they should remain protected for some hours. Dusting with a dry cloth or feather duster also stirs the microorganisms into the air; for this reason a damp cloth to which they will stick is greatly preferable for cleaning in kitchen, pantry, and china closet; in fact, everywhere. These considerations also show the great sanitary advantage of modern cleaning devices, of which a number of sorts are now on the market, by which the dirt is sucked through tubes into suitable receptacles. Bits of damp newspaper or damp sawdust sprinkled on a floor will hinder dust from rising when the room is swept, but the wooden or linoleum-covered floor of a well-kept kitchen and pantry should furnish very little dust. Larger particles should be lightly brushed up and the floor washed every few days.

PET ANIMALS IN THE KITCHEN.

Another possible source of danger, but one frequently overlooked, would seem to be the pet animals of the household. The fur of even the most cleanly cats and dogs must come in contact with many things which we would not care to have touch our food. In many families where the animals are not allowed in the living rooms for fear of soiling furniture they are given free range in kitchen and pantry, where the chances are they will leave more or less loose hair and dirt which may find its way to food utensils or to food.

A word should also be said regarding animal pests. Rats and mice are regarded by all housekeepers as destructive and disagreeable in every way, and no one cares to eat food which they have touched. Traces of the presence of mice may sometimes be noted in cereals and other foods sold from open boxes and similar containers in markets and shops which are careless in such matters. This suggests another reason for keeping such foods in glass jars or tin cans or similar receptacles in shops and in the pantry and storeroom. In addition to the food which they destroy and the pecuniary loss involved, rats and mice are a menace to health, as they are known to be carriers of disease. Many investigations have been reported which show their connection with the spread of trichinosis and with bubonic plague. Data summarized by the New York State Department of Health[a] indicate that the rat may be a large factor in transmitting diphtheria and other communicable diseases.

The question of the losses due to rats and methods for destroying these pests are considered in an earlier bulletin of this series.[b]

THE FOOD SUPPLY.

That food which is brought into the home shall be clean and of good quality is a matter of the greatest importance. Vegetables and fruits should be grown and milk and other dairy products produced under proper conditions (see pp. 13 and 17), and all the products of the farm and garden which pass through the dealer's or manufacturer's hands should reach the kitchen in a clean and wholesome condition.

Since the passage of the National Pure Food and Drugs Act, giving to the United States Government authority to enforce stringent laws against the adulteration and misbranding of foods which enter into interstate commerce, and the more rigid enforcement of similar state laws which regulate these matters in many of the States, a great burden has been lifted from the shoulders of the buyer. This legislation has enormously decreased the deceptions formerly practiced by some manufacturers, and since it insures that the name and description on bottle and package shall not misrepresent the contents, the buyer, if he knows what he wants, will have no difficulty in obtaining it, while the honest manufacturers and dealers (and they have without doubt always outnumbered the others) will also be protected. This matter in its various aspects is taken up in publications of the Bureau of Chemistry[c] of this Department.

The national laws regarding the inspection of meat and meat products are a further and very important protection of the home food supply. Publications of the Bureau of Animal Industry[d] of this Department deal with the question of meat inspection in relation to wholesomeness and quality. But the buyer has still to choose among many varieties of food that have all met the requirements of the law. There are, for instance, many kinds of canned vegetables that should be carefully compared as to flavor and water content. A 10-cent can of tomatoes that consists of a little partly ripened pulp swimming in water may be much dearer than a 15-cent can with a lower water content. The writer compared two cans of tomatoes on the basis of the amount of pulp of a given consistency that they yielded on straining. As the 15-cent can yielded twice as much as the 10-cent can, and the pulp was also of a better flavor, the cheaper can should really have sold for 7 or 8 cents in order to vie with the other in real food value.

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[a] Mo. Bul. N. Y. State Dept. Health, n. s., 4 (1909), No. 3, p. 74.

[b] U. S. Dept. Agr., Farmers' Bul. 369.

[c] U. S. Dept. Agr., Bur. Chem. Bul. 100; Yearbook 1907, p. 321.

[d] U. S. Dept. Agr., Bur. Animal Indus. Circ. 125.

CLEAN SHOPS AND MARKETS A NECESSITY.

The buyer as well as the merchant is responsible for the dirty market and shop, for if they were not tolerated by the purchaser they could not exist. The condition of the food when it enters the home is a matter of the utmost importance in relation to the subsequent handling and use, and great care is to be exercised in choosing clean rather than dirty places in which to purchase food. As yet the buyer has but little protection through the enforcement of law regarding unhygienic conditions existing in places where food is offered for sale. Let us hope, however, that this state of things will soon mend. In some States the boards of health are already active in the inspection of dairies, and the inspection of slaughterhouses has made great progress under the United States laws.

Even to the untrained eye the markets and provision stores are often dirty places. In too many of them all manner of foods are exposed to dust and flies, and in the long list may be found many that are "ready to eat," such as cooked meats, butter, cheese, bread, cake, figs, dates, pickles, and candy. In boxes on the floor, leaning at an angle against the counter, or on the pavement outside, may often be seen green vegetables, macaroni, and fresh fruits exposed to street dust which is in good part finely ground horse manure and other filth. A crate of berries may be seen on a stand outside unprotected from dust or from the visits of countless flies.

There are, of course, many market men and grocers who have clean, well-kept, and sanitary places of business, but the care of the market stall or provision store is too often in the hands of people who are not only ignorant of the hygienic reasons for avoiding dirt but also devoid of any real instinct for cleanliness, in so far, at least, as it applies to commercial matters. In such shops the meat block is seldom scraped and scrubbed, oysters are opened into dirty pails, and floors and shelves are infrequently cleaned. The grocer's assistant may come in directly from unharnessing the horse to take your crackers from the barrel, and his hands are not washed between drawing a fowl and cutting a beefsteak. The butcher or grocer's apron in a case recently noted served some of the uses of a handkerchief and yet it was in almost constant contact with food. Such topics are not pleasant, but conditions will not be mended until housekeepers take notice of such things, protest against them, and confine their buying to the shops which are run by men who can be trusted to abolish all such uncleanly ways.

If the average person finds these conditions and practices offensive, because they are unclean and unnecessary, how much more disturbed are those who have learned that in addition such practices involve bacterial contamination of foods, some of which are eaten raw.

The praise and blame of the buyer has much to do with keeping up the standards of the dealer, and it is held by some writers that the growing use of the telephone in ordering the dinner, thus bringing about absentee buying, is responsible for many bad conditions.

If buyers will think of these things and patronize the clean, progressive, and sanitary shops in preference to the others it will do much to insure better standards. It is the opinion of many, however, that the law is, or should be, the final resource. In some cities associations of housekeepers have joined in demanding better hygienic conditions in markets and have obtained what they sought.

SANITATION OF BAKERIES.

When we buy a loaf of bread in a shop whose counters are clean and whose show case carries a tempting array of cakes and rolls, we are not to conclude, as a matter of course, that the bakery at the rear or below stairs would also meet our approval. Not one customer in a thousand sees the conditions under which bread and pastry are manufactured, and it is this very removal from public view and criticism that constitutes the chief difficulty in enforcing existing laws for the proper construction of bakeries and for sanitary methods of carrying on the business.

Not long ago one-half the bread consumed in London came from cellar bakeries, and while it is true that a cellar bakery may be hygienic, the chances are strongly against it.

There are, of course, very many sanitary and clean bakeries and workmen who are careful in their work and neat in habits, but the reverse condition too often prevails. One London bakery is described in a recent report as 30 feet long by 7 or 8 in width, with bags of flour ranged on one side and the dough tubs placed along the other. In the same room were found open sanitary arrangements, poor sewerage leaking out foul gases, a defective oven letting out fumes of coal gas, open cracks in the ceiling through which sifted dust from the store above, and the stifling air was unchanged by ventilation.

In one of our Northern States a few years ago health inspectors examined 547 bakeries in 25 towns and 3 cities and reported that from a sanitary standpoint 270 were distinctly bad, 222 not especially bad, 44 satisfactory, and 11 worthy of especial commendation.[a] Similar conditions have been found in other localities.[b]

Most difficult to change are the personal habits of the workmen where they are careless and lacking in cleanliness.

In some bakeries floors and even vats were scrubbed but once a year; in some there was no provision made for washing the hands.

From such bakeries most persons do not care to buy their bread, if they are willing that men should be allowed to labor in such surroundings. It should not be forgotten that the buyer of food has many opportunities to help in raising standards that will affect the whole community. It is quite within the rights of the buyer to insist on inspecting the place where the food is prepared, but it is better to accompany the official inspector. Some of the bakeries will be found above reproach, and these are the ones which the careful housewife should patronize.

The inspection of bakeries is provided for by legislative enactments in some cities and States and is an important hygienic measure. Great improvements have been made in recent years in the construction of bakeries and in bread-making machinery and other equipment, all of which makes for more sanitary conditions. It is encouraging to note that progressive bakers realize the importance of cleanliness and sanitation and manifest a marked interest in all that pertains to such matters. As an instance of this may be mentioned the work of the bakers' institute in one of the Western States.[c]

It has been proposed that a law should require that the loaf of bread, as soon as baked, should be put in a paper bag and thus handled and transported, but it is sometimes difficult to carry out reforms of this kind if they conflict with the prejudices of the buyer. A baker in one of the large cities whose methods were known to the writer started this method but did not succeed in popularizing it. People wanted to "see the bread," and it entailed an expense which the buyer was not willing to meet and which the baker thought that his profits would not warrant. Other cities or other bakeries have without doubt had a different experience. At any rate, bread or rolls thus wrapped in paper, often of a transparent nature, are served in some restaurants and hotels and on some dining cars.

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[a] Mass. State Bd. Health Rpt., 38 (1906), p. 607.

[b] Bien. Rpt. Bur. Labor and Indus. Statis. Wis., 13 (1908), pt. 5.

[c] Bien. Rpt. Bur. Labor and Indus. Statis. [Wis.], 13 (1906–7), pt. 5, p. 719.

THE QUALITY OF MEATS.

In order to become a good judge of meats it is very helpful to have a few lessons from an experienced buyer. The different cuts will thus be easily learned, but the quality of the meat depends on so many factors, as the age of the animal, the breed, and the method of fattening, that it is easy to make mistakes in choosing, and the buyer will often be wise in accepting information from the dealer, if he is one who prides himself on keeping first-class meats. Having found such a one, the customer who wishes to save time and money will continue to buy of him. The very large amount of meat which some housekeepers provide is not necessary. In general it is better to use a reasonable amount of that which is in prime condition rather than to economize on the quality. The meat is easily supplemented by other dishes, and the whole meal will thus be better balanced than would be the case if a larger amount of inferior meat were provided. Although not generally understood, it is just as important that the cheaper cuts of meat, as well as the dearer ones, should come from a well-fattened animal.

THE TRUE PRICE OF MEATS.

There is an apparent and a true price of meats, a fact that is not always considered. It may be more economical to pay 15 cents for a cut of clear meat than 8 cents for one that contains nearly half its weight of bone, sinew, and fat. The apparent price of chicken may be 20 cents a pound, but its real price will often be 50 cents, when the weight of head, legs, entrails, crop, and bones is taken into account.

POULTRY.

There is much discussion regarding the merits of drawn and undrawn poultry. Most dealers contend that in warm weather a fowl which has had entrails and crop removed spoils much more quickly, because of the extent of cut surface exposed, than does undrawn poultry. The writer found in a large city market but one dealer who kept drawn poultry, and he said that he could not do so except for the fact that steady customers took all of his stock, so that nothing was left on his hands. The extra price that he charged per pound was only sufficient to make up for the loss in weight.

The Massachusetts State Board of Health[a] has recently studied this question and found that if the entrails were so drawn that none of their contents were spilled inside the body, the bird kept better than in the undrawn state. The work of the Bureau of Chemistry on this subject is referred to later. (See p. 26.)

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[a] Mass. State Bd. Health Rpt., 39 (1907), pp. 265, 287.

It is greatly to the housekeeper's advantage to buy fresh, well-drawn poultry, for not only is the flavor injured by the unclean practice of allowing the entrails to remain in the body, but it is thought to favor the development of ptomaines. It has been shown that after death the intestinal juices with their contained bacteria are able to pass through the walls of the intestines into the muscle fiber, and this process goes on even though the fowl is kept at a very low temperature. In some States cold-storage fowls are required by law to be sold as such.

FISH.

Regarding fish, one quality is so all-important that the buyer is warranted in giving the order: "Any kind that is fresh." The dealer knows what he is selling. The buyer may not be able to discover from lack of experience in the effect of ice and cold storage. It is safe to rely on a good dealer if the buyer is a good judge of fish when it comes on the table and then holds the dealer strictly to account. Fish that has been kept for a week or more on ice has lost its distinctive flavor, although it may not be spoiled. It has what the cook calls a "woolly" taste. Shellfish form a delicious addition to the diet, but if they have been grown or fattened in sewage-infected water they may carry disease germs. As it is in general impossible to learn their origin, the rule of never eating them in the raw state is adopted by many. The practice of fattening or "floating" oysters in fresh or in brackish water robs them of much of their fine flavor, and since the most accessible supply of such water is at the outlet of streams, and as such streams are frequently polluted by sewage, many persons believe that this practice should be forbidden by law.

In many European cities fish are sold alive, the customer selecting his fish as it swims in a tank. It would seem that this excellent method might be used in our own cities, especially those situated on the seaboard, at least for customers who are fastidious and who are willing to pay an extra price for special articles when it is warranted.

VEGETABLES.

Only those who have been accustomed to eating green vegetables fresh from the garden realize in what poor condition are many of the vegetables sold to the city buyer. Some varieties, as green peas, are so delicate in flavor that even a few hours' removal from the vines brings about a change. Indeed, the market gardener has been obliged to develop the keeping qualities of vegetables and fruit at the expense of flavor.

If lightly packed and transported only a short distance, the deterioration in most vegetables is not noticeable, but if closely packed for any length of time changes due to the action of enzyms or "ferments" normally present in the living tissue take place, with a consequent loss of flavor.

In green corn, for example, the ferments present begin immediately to destroy the contained sugar, and thus the corn is robbed of flavor very shortly after picking. These changes are often accompanied by changes in appearance by which they may be detected, especially in green corn and in peas and beans. Pods inclosing peas should be crisp and plump. String beans should not have a faded look or any suspicion of toughness or limpness when broken. Green corn should show fresh husks or "shucks" of good color, not wilted or partly dry, nor lacking the "bright" look of the fresh ear. Cabbages should be crisp and bright of color. Cucumbers, turnips, and carrots should be firm to the touch. Lettuce, if of the headed variety, should have firm, bleached hearts, showing no trace of the rusty red look that announces long keeping. It will keep its freshness longer if the root is left on.

Some market men and grocers grow part or all of their own vegetables, and make a practice of having only fresh ones of good quality in stock, though the combination of market gardener and grocer is, in the nature of things, not common. A much larger number of market men and grocers are very particular to procure for sale only fresh vegetables, and here again the discriminating buyer will patronize the dealer who is to be trusted.

When housekeepers buy vegetables of peddlers, they should patronize, if possible, the grower rather than the huckster. The grower must sell out and go home, and it is to the huckster that he sells his surplus, and this surplus is often so manipulated as to sell for fresh goods until the next market day. The huckster in his off hours may often be seen trimming off the wilted outside leaves of celery, cabbage, and lettuce and giving a fresh surface to the stem, and sometimes rinsing or sprinkling the lettuce with water not infrequently far from clean. The beets which were left over, after losing little by little their tops, are sold by measure to whoever will buy.

It may be said in general that when a given vegetable is cheapest then it is best, for all conditions are then favorable to its development. Potatoes should be bought in a fully ripened state, not too young, nor is it necessary to eat them when they have become too old, as it is easy to find substitutes such as boiled rice, hominy, and similar foods.

Vegetables of medium size, neither very large nor very small, will be generally found to be the best, and most housekeepers consider them the most economical, as they may be cooked and served with least waste.

THE STORAGE OF FOOD.

In earlier times a larger proportion of the food supply was stored at home than is now the case. Even in cities and towns supplies were commonly purchased in bulk. Owing to the improvement in transportation facilities and to other changed conditions storage of food outside the home has developed into an enormous industry. As was the case with markets and food manufactories, the storage plant is a matter in which the housewife is interested, as it has to do with the character of the food which comes into the home.

COMMERCIAL COLD STORAGE.

Cold storage as applied to whole carcasses of beef and mutton has been of great service to the buyer. By its aid prices are equalized and we are furnished even in summer with meat that has been made tender by keeping.

The service rendered by cold storage of fish and poultry is not so thoroughly well established. The subject is being carefully investigated by experts. Apparently, if the process is carried out in the best manner and the goods not kept too long in storage, the cold-storage fish and poultry are wholesome. From the results of an investigation of the quality, flavor, and wholesomeness of cold-storage turkeys, drawn and undrawn, the changes brought about by storage, and similar matters carried on for the Buffalo, N. Y., Department of Health,[a] the conclusion was drawn that under proper regulation cold storage can be safely employed for poultry, but that regulation is essential. The question of the effects of cold storage on the character of meat and other food products, the comparative merits of drawn and undrawn poultry, and similar matters are being investigated by the Bureau of Chemistry of this Department and are discussed in its publications.[b]

With all cold-storage foods it is important that there shall not be a long interval between removal from storage and cooking, and this is particularly the case with poultry and fish. Foods that have been frozen and then thawed seem to furnish particularly good ground for bacterial growth, or what we call "spoiling."

Storage of fruits and vegetables, which is coming more and more into use, gives us many out-of-season articles. The same is true to a great extent of turkeys and other domestic poultry, for food of this kind is largely of seasonal production, and cold storage seems to be the only method by which the fresh material can be kept for a long period for market purposes. In the case of many sorts of cold-storage fruits and vegetables it is the common opinion that their quality is hardly as good as that of fresh ones. On the other hand, if handled under the best conditions much of the cold-storage goods, such as apples and other fruits, is of excellent quality. Indeed, it is difficult to imagine how housekeeping could be carried on, particularly in large cities and towns under modern conditions of home construction (with limited storeroom, etc.) without the cold-storage industry. For this reason it is all the more important that the housewife should be informed as to the best ways to handle such commodities, and should use her influence to insure the best conditions in the cold-storage industry.

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[a] Buffalo [Dept. Health] Sanit. Bul., n. ser., 2 (1909), No. 3, p. 1.

[b] U. S. Dept. Agr. Yearbook 1907, p. 197; Bur. Chem. Bul. 115.

THE STOREROOM IN THE HOME.

The storeroom for food may be the tiny closet of the flat dweller in a city or the cellar of the village or farm house. In the last case it often has a commercial as well as a household value, since it keeps fruits and vegetables in good condition until marketed, as well as until they are needed for the home table; but in any case, it should be cool, dry, clean, and regularly aired.

It may be well to describe a cellar that is badly built and carelessly kept, in order to see what should be exactly opposite conditions.

Such a cellar may be dug in wet ground, without sufficient drainage of the subsoil; it may even be in contact with open sewers or drains, which have been proved in certain cases to contain specific organisms capable of producing disease. In many cases the cellar built against an earth wall is not protected from dampness by a layer of moisture-proof cement, and the water may stand in drops on its surface. Again, it may be dug to such an extent below the surface of the ground that the windows are wholly inadequate for lighting and ventilation.

It may have an earthen floor, or one of badly matched boards impossible to keep clean. It will probably have a musty smell, proof positive that mold plants are there and ready to attack any fruit and vegetables stored on its shelves or in its dirty bins.

If, in addition to this faulty construction, the cellar is badly kept, bits of rotting fruit and vegetables being left about, not only will these conditions favor the spoiling of food, but they may prove injurious to the health of the family living above stairs.

A cellar that meets modern requirements must be dug in ground that is well drained either naturally or by artificial means. It must be remembered that a cellar is not, first of all, a storeroom; it is an essential part of a well-planned house, especially necessary in our Northern States, in helping to keep an equable temperature; and if its walls and floor are what they should be it prevents dampness and ground air from rising into the house.

If the house is set close to the ground the cellar windows must be wide enough to compensate for their lack in height, and must be set opposite each other in order to insure good draft. A method that is sometimes used is to dig out a space in front of a window, making a little area which, laid in either brick or stone, may be whitewashed and reflect light into the cellar, as is shown in figure 1; it also allows of sinking the cellar window deeper and obtaining better ventilation. This matter and related topics are considered in a recent volume[a] on farm home construction and similar questions.

The walls and floor of this cellar should be laid in Portland cement to keep out moisture, and the walls and ceiling should be whitewashed twice a year. Even if a cellar is kept very clean, the earthy smell of vegetables that arises from it when it is well stocked is not agreeable—another reason for good ventilation and frequent airing. A separate room may be partitioned off from the cellar in one corner for storage purposes. This can then be kept darker than one would wish to keep the rest of the cellar. Such a room must, of course, be aired now and then. In this storage room should be placed a movable safe with wire-netting sides, and a swinging shelf; and broad shelves should be built high enough so that barrels may be shoved under them.

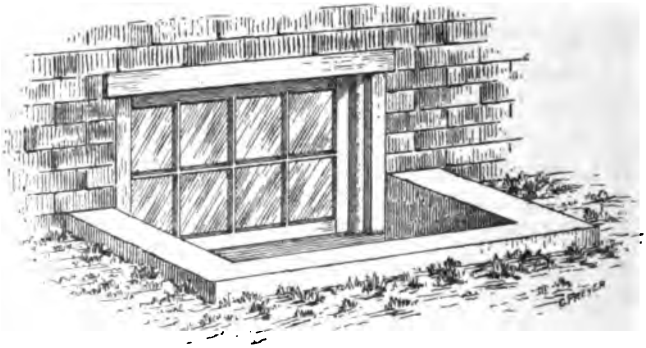

FIG. 1.—Cellar window constructed to secure ventilation.

The writer once saw in Holland a cellar that met every possible requirement of hygiene. The floor and side walls were of closely matched tiles laid in cement, making it as tight as a dish and as easily cleaned. It was not large, but its wall space was so utilized that it furnished ample storage facilities for a large restaurant.

HOT-WEATHER STORAGE.

The storage of food in cold weather is a comparatively simple matter, since the low temperature, which is a prime requisite for checking the growth of bacteria and molds, is furnished by nature and we have only to guard against freezing. The keeping of perishable foods in warm weather is best accomplished by artificially cooled air.

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[a] The Healthful Farmhouse. Boston, 1906.

ICE MACHINE.

If the household is large enough, it may make use of the ice machine driven by an electric motor of one-eighth horsepower, or by a gas or some other suitable engine, which operates a brine tank and furnishes to the ice chest dry air as low as 42° F., with a cooling power equivalent to 200 pounds of ice a day. Such clean, dry air at a constant low temperature furnished from outside is so superior a method of cooling food that the ordinary ice chest seems a poor thing in comparison, though in the majority of homes it is the only resort.

ICE CHESTS.

There are many varieties of ice chest or refrigerator, all built on one of two general plans. In one kind both ice and food are kept in one large compartment. In the other the ice is placed in a top compartment, below which are cupboards for the food; the principle here utilized is that cold air seeks a lower level and that the air cooled by the melting ice will sink to the shelves below. It probably better utilizes a given amount of ice, for the further reason that the ice compartment may remain tightly closed except when being filled. In both cases the air space between the outside wall and the zinc lining is filled with some nonconducting material, as cork or asbestos.

It is of great convenience to have the ice chest built against the outer wall of kitchen or pantry, so that it may be filled from the outside by means of a small door cut for that purpose. In such a case it is of course advisable to choose a wall on which there is little or no sunshine. The ice box may also be drained by a pipe leading to the outside and then properly cared for, thus saving much labor in the emptying of pans. It is not considered safe to connect it with the house sewer because of the danger of sewer gases "backing" into it, even if a good trap is provided.

CARE OF ICE CHESTS.

If on a warm summer day you put your hand into an ice box well filled with ice you may think that the temperature is very low, and yet it is in all probability nearer 50° than 40° F. As low a temperature as 40° or 45° is only to be obtained in a very well-constructed box with a large receptacle for ice, and then only for a short time after it is filled. A box that maintains but 60° is, however, very useful in keeping food from day to day.

The ice box, no matter how well cooled, is and must be damp, and dampness is one of the requirements for bacterial growth. It must be remembered, also, that some varieties of bacteria grow at low temperatures. Therefore the interior of an ice chest should be wiped every day with a dry cloth and once a week everything should be removed, so that sides, shelves, and drain may be thoroughly scalded. The water must be actually boiling when it is poured in, and the process repeated several times.

In the small ice chests, where all the ice space must be utilized, the cube of ice will be a tight fit, and it is difficult to lower it to the grating. If the ice is put on a piece of stout cloth whose ends are long enough to reach above the top, it may be lifted by these ends and easily deposited in place. The cloth folded about it serves also to protect the ice from the heat of the outside air, and holds any bits of dirt that may have been frozen into the ice, thus preventing them from settling to the floor of the box or lodging in the drain pipe. The cloth should be scalded after each using. A folded newspaper laid on the floor of the one-compartment ice box serves the same purpose as to cleanliness. It must be remembered that refrigerator ice is often dirty, and that it may bring in putrefactive or even typhoid bacilli, for most bacteria are resistant to low temperature and are not destroyed by freezing. On this account no food should be brought into direct contact with it, nor should it be put into drinking water, unless its purity is above suspicion.

All cooked food should be cooled as soon as possible before being placed in the ice box. Butter may be kept from taking up the flavors of other food by keeping it in a tightly covered receptacle. Milk requires more access of air, but in a clean ice box in which no strong-smelling food is kept milk should remain uninjured in flavor for twelve to twenty-four hours. If vegetables or other foods of pronounced odor are kept in glass jars with covers or in covered earthenware receptacles there will be fewer odors to be communicated. Portions of canned food should never be put into the ice box in the tin can. Such food does not of necessity develop a poisonous product, as has sometimes been claimed, but experiments show that ptomaines are particularly liable to develop in such cases. Casting out this somewhat remote possibility, the "tinny" taste acquired by such keeping is enough to condemn the practice.

Foods that are to be eaten raw, such as lettuce and celery, should be carefully cleaned before being placed in the ice box, and may with advantage be wrapped in a clean, damp cloth. If they are to be kept for some days they should, however, be put in without removing the roots, the further precaution being taken to wrap them carefully in clean paper or to put them into grocers' bags.

WATER FOR COOLING FOOD.

There are many ways of lowering temperature by utilizing the fact that water when evaporating draws off heat from surrounding objects. If a pitcher of water be wrapped with a cloth which is kept saturated and exposed to a draft of air the temperature of the water in the pitcher will be lowered by several degrees.

A receptacle in which food is placed may be cooled in the same way. Take a wooden box with a sound bottom made of one piece and invert it. Tack a layer of cotton batting over it and cover with some coarse cloth. It is now to be kept wet by some contrivance that will furnish an automatic drip. The writer used for this purpose an old aluminum pan which had in it a half dozen very tiny holes, and when filled with water it supplied just enough water to keep the cloth saturated. Under this box lettuce in cold water, a cold pudding, a pat of butter, and other food were placed and kept in good condition. A pan of milk lowered into another of cold water is kept from souring many hours longer than if it was unprotected from the surrounding air. Spring water of low temperature is used by many farmer's wives to keep milk and butter cool, and a "spring house" is a common thing on many farms, though less depended upon than was the case before ice houses, refrigerators, and ice chests became so common.

It is also an old-fashioned practice to lower foods in covered pails into the well and suspend them not far above the surface of the water.

WINTER STORAGE OF FOOD.

In the Southern States storage problems are not the same as in regions where the winter is severe, and many roots and other vegetables may be left in the ground with little or no protection, while crops may even be grown throughout the year, thus doing away largely with the need of winter storage. In the greater part of the United States, however, the problem of keeping at least a part of the food supply through the cold season is an important one, and the more important the longer the winter season.

The farmer will without question keep in cellar or storeroom or outside cave or pit the surplus of what is raised on the farm. Whether it is wise for others to buy food in large quantities and store it for winter use depends on whether it can be bought at a sufficiently low price to pay for the care and risk that the keeping entails, as well as on market facilities, the amount of storage space available, and similar factors. But the storing of smaller quantities of food is both convenient and economical and is an absolute necessity for families who live at a distance from market.

A WINDOW STORAGE BOX.

The dweller in a small apartment who has no cool cellar in which to store perishable articles may find an outside window box useful in winter.

A carpenter may be hired to construct a box that will exactly fit outside a kitchen window, if possible on the north side. Such a device has been described in a number of books and bulletins.[a] It should come halfway up the lower sash and contain two deep shelves, and when the sash is raised the contents of these shelves are easily accessible. In freezing weather the sash may be left up, and thus the box becomes a part of the warmed room. A sash curtain will conceal it from the room. Such a window box is often fully as great a convenience in the farm or village home as in the city flat. Figure 2 shows a way in which it may be constructed.

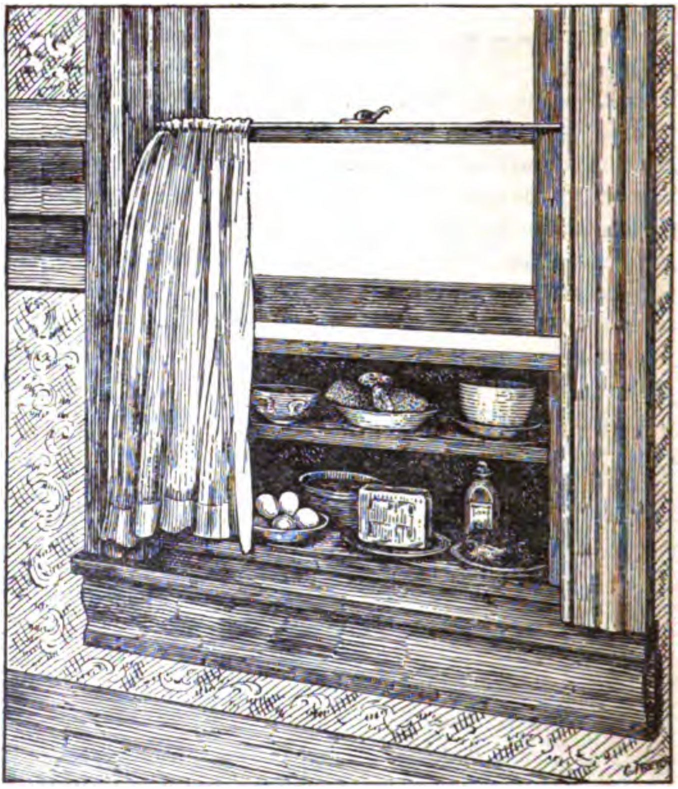

FIG. 2.—Window box for storage of food.

A more inexpensive way is to hang a neat wooden box, well cleaned, on strong nails or spikes outside the window. A heavier box may be supported on brackets. The box should have a tight-fitting hinged lid and be lined with asbestos paper to equalize extremes of temperature, while a lining of oilcloth will admit of easy cleaning. A shoe box would be good for this purpose. It might be painted the color of the house.

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[a] Cornell Reading Course for Farmers' Wives, 1. ser., No. 1, p. 6—Farm House and Garden; No. 3, p. 52—Housekeeping; also Reading Lesson Sup. 1.

THE KEEPING OF VEGETABLES, FRUITS, AND MEATS.

The following hints regarding the keeping of different kinds of food may be found useful:

Potatoes are kept without difficulty in a cool, dry, and dark place. Sprouts should not be allowed to grow in the spring.

Such roots as carrots, parsnips, and turnips remain plump and fresh if placed in earth or sand filled boxes on the cellar floor.

Sweet potatoes may be kept until January if cleaned, dried, and packed in chaff so that they will not touch each other.

Pumpkins and squash must be thoroughly ripe and mature to keep well. They should be dried from time to time with a cloth and kept, not on the cellar floor, but on a shelf, and well separated from each other.

Cabbages are to be placed in barrels, with the roots uppermost.

Celery should be neither trimmed nor washed, but packed, heads up, in long, deep boxes, which should then be filled with dry earth.

Tomatoes may be kept until January, if gathered just before frost, wiped dry, and placed on straw-covered racks in the cellar. They should be firm and well-grown specimens, not yet beginning to turn. As they ripen they may be taken out for table use, and any soft or decaying ones must be removed.

Apples, if for use during the autumn, may be stored in barrels without further precaution than to look them over now and then to remove decaying ones; but if they are to be kept till late winter or spring they must be of a variety known to keep well and they must be hand-picked and without blemish or bruise. They should be wiped dry and placed with little crowding on shelves in the cellar. As a further precaution they may be wrapped separately in soft paper.

Pears may be kept for a limited time in the same way, or packed in sawdust or chaff, which absorbs the moisture which might otherwise favor molding.

Oranges and lemons are kept in the same way. Wrapping in soft paper is here essential, as the uncovered skins if bruised offer good feeding ground for mold. Oranges may be kept for a long time in good condition if stored where it is very cold but where freezing is not possible. Lemons and limes are often kept in brine, an old-fashioned household method.

Cranberries, after careful looking over to remove soft ones, are placed in a crock or firkin and covered with water. A plate or round board placed on top and weighted serves to keep the berries under water. The water should be changed once a month.

In winter large pieces of fresh meat may be purchased and hung in the cellar. Thin pieces, as mutton chops, are sometimes dipped in mutton suet, which keeps the surface from drying and is easily scraped off before cooking.

Turkeys, chickens, and other birds should be carefully drawn as soon as killed and without washing hung in the coolest available place.

Smoked ham, tongue, beef, and fish are best put in linen bags and hung in the cellar.

Salt pork and corned beef should be kept in brine in suitable jars, kegs, or casks, and should be weighted so as to remain well covered. A plate or board weighted with a clean stone is an old-fashioned and satisfactory device.

Eggs may be packed for winter use in limewater or in water-glass solution, methods which are described in an earlier bulletin[a] of this series. Many housekeepers have good success in packing them in bran, in oats, or in dry salt, but according to experiments summarized in the aforementioned bulletin, the preference is to be given to the 10 per cent solution of water glass. Exclusion of the air with its accompanying micro-organisms and the prevention of drying out are what is sought in all cases. Packed eggs are not equal to fresh eggs in flavor, but when they are well packed are of fairly good quality and perfectly wholesome.

STORAGE OF GROCERIES, MEATS, COOKED FOOD, AND CANNED GOODS.

Flour comes packed both in barrels and in bags, and the form in which it shall be purchased and kept is of importance to the housewife. Bags have certain advantages over the barrel for both producer and consumer; they pack into freight cars with no waste of space, and the cloth for 8 bags costs less than one barrel; for the consumer, also, it is often convenient to buy in small quantities. But, on the other hand, the bag is too often very flimsy in texture, so that it allows flour to sift out, and is also easily soiled by contact with a damp or dirty floor. The purchaser may well require that the bags be made of good material, so that the contents may be protected from dust and dirt.

On this question Prof. Harry Snyder, of the University of Minnesota, says:

> There is no question whatever but what flour improves by storage up to six months and it will then hold its own for some time, depending upon the character of the wheat and the thoroughness with which impurities are removed.
>
> As a general proposition it seems certain that it is economical for the consumer to buy flour in bulk rather than in small sacks at a time. In the fall of the year a small sack of flour for trial purposes can be purchased of the grocer and at the same time he can set aside a barrel of the same flour of the same shipment for future delivery, provided the first sample proves satisfactory. As a general rule the price of flour advances from fall to spring sufficient to more than cover the interest item involved and at the same time the consumer is assured of a good quality of flour.

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[a] U. S. Dept. Agr., Farmers' Bul. 128.

Aside from accidental contamination the chief destructive agencies in stored flour and similar materials are fungi and bacteria. The fungi or molds break down chiefly the starches of the flour, forming organic acids which make the flour sour. The bacterial growths which are present are chiefly forms which liquefy or break down the gluten, the acid presumably aiding in this. This matter has been studied by H. G. Bell,[a] among others, in connection with the problem of commercial storage, and he recommends storage in well-lighted, warm, and dry rooms as a preventive of the development of fungi and bacteria, a method as applicable to farm and town homes as to commercial conditions.

The various prepared or "self-raising" flours are more expensive than the mixture that the housewife can easily make by adding the requisite amount of baking powder to flour and sifting it several times. It is a convenience and a saving of time to keep this mixture on hand, as one sifting provides enough for a month's use in cakes and muffins.

The fact that many breakfast cereals that were once sold only in bulk can be bought in packages is a great advantage from a sanitary point of view. The contents of these packages, if bought fresh and if well cared for, will remain in good condition for months. If made in clean factories, such goods have had little chance for contamination from dust and dirt.

If breakfast cereals are bought in bulk they should be kept in tight receptacles in a cool, dry place. Crackers may be kept like breakfast cereals, either in the packages, in which many sorts are marketed, or in tin boxes or in jars.

Corn meal spoils more readily than flour, and for most families it is best to buy in small quantities.

Rice, tapioca, macaroni, and similar dry materials may be kept without any trouble in covered cans or small crocks in a dry, clean place. The same method is advisable for raisins, Zante currants, evaporated and dried fruits, and similar supplies.

Sugar and salt are best kept, the former in tin, the latter in wooden or crockery receptacles.

Glass preserve jars are perhaps the best and most convenient of all containers for small quantities of almost any food material.

BREAD AND OTHER COOKED FOODS.

While cooling, newly baked bread should be lightly covered with a clean cloth or paper to prevent mold germs and dust from falling upon it, but should not be tightly wrapped in a thick cloth as is the practice in some households, for unless it is aired when taken from the oven, it is likely to become "soggy" and damp and thus offers an excellent medium for cultivation of molds. When perfectly cold the bread should be placed in a close receptacle that has been thoroughly scalded and aired. If bread is to be kept for more than two or three days in damp, hot weather, the jar or box should be taken out and sunned for a short time now and then, and again scalded and dried. On no account should portions of a former baking be stored with a new batch.

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[a] Oper. Miller, 13 (1908), p. 591; Amer. Miller, 37 (1909), p. 280.

Cake and cookies should be cooled after baking and kept in tin boxes or in earthenware jars, which, like bread boxes, should be often scalded and aired. Even if these foods are to be eaten at the next meal it is well to keep them in some such receptacle, as it insures protection from dust. A cake, pudding, or pie put out of a window uncovered to cool or in any other place where it is exposed to dust, and in summer also to flies, is something that no careful housewife would place on her table if she stopped to think how easily the food may be contaminated.

CANNED FRUITS AND OTHER CANNED GOODS.

Commercial canned goods may be advantageously bought by the dozen in the autumn, and they do not seem to suffer from even a poor storage place, provided it is not so damp that the cans rust through. If dirty or dusty, the cans should always be carefully wiped before they are opened to prevent accidental soiling of the contents.

Vegetables and fruits canned at home and homemade jellies, jams, and similar foods should be kept in dry, airy storage places, out of direct light. The cans and jars used should be of good quality, and all the usual precautions of good rubber rings (if they are used), and so on, should be taken. These matters are discussed in earlier bulletins[a] of this series.

Canning may also be made use of daily for temporary preservation of food, and it is especially valuable where ice-chest facilities are not good. When making soup stock a large quantity is made as easily as a small, and the surplus may be poured, while hot, into fruit jars and sealed. Boiled milk may be thus canned and cooked vegetables which may be at the time plentiful or cheap. Mince meat may also be canned, but it will keep a long time in an ordinary receptacle if melted suet be poured over the top.

Such canning, especially of soup stock or milk, is only recommended for a few days' keeping, and every precaution should be taken that is familiar in the ordinary canning of fruit or vegetables.

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[a] U. S. Dept. Agr., Farmers' Buls. 203 and 359.

LABELING FOODS IN PACKAGES AND CANS.

Many otherwise good housekeepers are very indifferent about labeling. They trust to their memory as to what is in each jar or package, and sometimes with disastrous results. All stores should be plainly labeled.

CARE AND UTILIZATION OF FATS.

Fats that are derived from the cooking of bacon, ham, chicken, beef, and other meats, should be kept, each in its own receptacle, to be used for different purposes.

Home rendering of both suet and leaf lard has its advantages, because the product is generally superior to what can be bought for the same price.

Both suet and leaf lard require cooking in order to loosen the fat from the tougher membrane that holds it. For this purpose the material is cut in small pieces and covered with water and allowed to cook slowly for some time until no more water remains and the scrap has turned to a light brown.

A better method for suet is that used by German housewives, who economize on butter by the use of beef fat more than do American housekeepers. The suet is cut in small pieces and covered with water, in which it is allowed to soak for a day, the water being changed once in the time. It is then drained and put into an iron kettle with one-half teacup of skim milk to every pound of the suet. It should be cooked very slowly until the sound of boiling entirely ceases. When it has partly cooled, it should be carefully poured off. This fat has no unpleasant taste or odor, and in many recipes may be substituted for part of the butter. Some cooks add a pound of leaf lard to 4 or 5 of the suet; this makes a softer fat, as lard has a lower melting point than beef fat.

An old-fashioned method of clarifying fat from the soup kettle, or from cooked meats, so that it may be used in the kitchen, is to add the cold fat to a liberal quantity of cold water, then heat slowly and let cook for an hour or more. When cold, the cake of fat is removed and the lower portion, which will contain the small particles of meat, etc., should be scraped away and the white, clean fat saved. If the flavor or color or both are not satisfactory the process may be repeated several times. Another method which is often recommended is to cook a number of slices of raw potato in the boiling fat.

When an ice chest is used fat in small quantities may be easily kept sweet for cooking purposes. If lard is rendered at home in quantity sufficient for a long time, it should be kept covered in tins or earthen jars, in a cool, dry place, as in a cellar or storeroom.

In some families where fat from cooked meats is not used in the kitchen it is made into soap for laundry or even toilet use. Directions for making soap at home may be found in most good books on housekeeping. Some questions concerned with soap making at home are considered in a discussion of laundry and other cleaning problems by Miss Rose,[a] of the Home Economics Department of the Agricultural College at Cornell University.

Cooking butter may be bought at a lower price than table butter, but it should be rendered before using. It may be found to have some degree of rancidity, and to correct this condition there must be mixed with it one-fourth to 1 teaspoonful of baking soda to the pound. It should be melted and cooked down slowly until the froth rises and the sound of cooking ceases, then skimmed and poured off carefully from the dregs. Unless to be used immediately, one-half tablespoonful of salt per pound should be added. One-third less of this clarified butter is equivalent to the quantity of ordinary butter called for in any recipe. In India and some other tropical countries this rendered butter, called "ghee" or some other special name, is a product much used by the native population, and through their example by others, who have found by long experience that butter will keep in good condition in this form while it would generally spoil if stored as made.

HANDLING OF FOOD AND UTENSILS IN THE KITCHEN.

The handling of food before it reaches the home is a matter of the greatest importance to the housekeeper, as it has a very important relation to the condition of the food and to its keeping qualities, wholesomeness, and other characteristics after it is purchased.

In preceding sections it has been shown what are the dangers from market dirt and dust, from flies and other animal life, from the soiled hands and garments and utensils of butcher and grocer, milkman, and delivery boy. It is not too much to say that when the food reaches our door much of it is an object of suspicion, and this will be the case until market inspection is far better than at present. But we have now to consider what treatment shall be given to perishable food when it comes into the kitchen.

MEATS.

The dealer must be especially enjoined to tie up the meat in a secure package, else the brown paper in which it is loosely wrapped will not protect it thoroughly in transit. This paper should not go with the meat into the ice box.

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[a] The Laundry: Cornell Reading Courses for Farmers' Wives, n. s. 1, Sanitation, 1909, No. 3.

When meat is received the skin side should be rubbed with a cloth wet in hot water and then carefully scraped with a knife. The thin outer skin of lamb should be entirely removed in order to avoid the disagreeable taste due to any contact with the hair of the animal. The cut surface should also be carefully scraped, and, to prevent drying, be covered with paraffin paper or rubbed with salad oil, or, in case the meat is to be kept for some time, entirely covered with melted suet. The meat should then be put on a plate in the ice box.

POULTRY.

The skin of poultry is frequently very dirty when brought from market and fowls should be not only washed, but scrubbed with a soft brush and warm water in which a teaspoonful of baking soda has been dissolved. Such treatment will prevent the disagreeable "henny" taste often noticeable in cooked poultry.

Poultry should be drawn immediately, and unless it is known to have been killed very recently it should be thoroughly washed on the inside and used soon. Poultry that is drawn directly after killing, on the contrary, keeps better if it is not washed until used. (See also p. 23.) It should be hung in a cold place or put in the ice box with a piece of charcoal inside the body.

Cold-storage chickens should under no circumstances remain in a warm room before cooking. Such poultry must be kept at a low temperature and cooked as soon as possible. All cold-storage food when brought into a warm temperature spoils quickly, and without doubt many cases of illness traced to the use of such food are really due to careless handling and delay in cooking.

WASHING VEGETABLES.

If deteriorated vegetables are brought into the kitchen no method of handling will restore them to first-class condition. Even good ones will not be at their best unless they are properly cared for after being received. After all that has been said in this bulletin regarding the possibilities of dangerous micro-organisms having lodged upon vegetables, it may seem superfluous to insist again that any which are to be eaten raw should be thoroughly washed. It is of course useless to wash them with water which is itself dangerous, and in any case where the water supply is not considered safe for drinking, boiled water should be used for washing vegetables and fruit after the first rough dirt has been removed by hydrant water.

As to the method of washing vegetables, a few cautions are in order. Some people never choose asparagus at table unless it has been prepared by some one who is very careful, as they do not wish to bite down on sand, for the cleaning of this vegetable requires conscience as well as care. The bunch should be placed, heads down, in water for some hours and should be shaken back and forth to dislodge the particles of earth. Spinach is another vegetable which requires the best cleansing to free it from grit. After the roots have been cut off it should be washed in a number of waters and lifted out of the pan each time in loose handfuls before the water has been drained off.

Celery and lettuce and other salad plants, because eaten raw, must be washed with the greatest care. They should be searched leaf by leaf for insect life, washed in several waters, and then wiped dry with a clean cloth and put in a cold place to become crisp.

WASHING FRUITS.

A German investigator, B. Ehrlich,[a] having estimated by careful experiments the number of bacteria to be found on market fruit, tried different methods of washing it without injuring the flavor. He washed grapes, apples, and pears that had been exposed to street dust, each time examining the wash water for the number of bacteria present. While the first wash water yielded large numbers, the second contained only a few, and the third a negligible number. A basin of water was used for the purpose, the fruit being moved about in it. When running water was used, five minutes' time was allowed. Fruits with a firm, smooth skin should be rubbed before washing with a clean cloth to start the dirt.

The cleaning of delicate berries is a difficult matter. Such fruit should be purchased with care to avoid all that are too soft or which show sand or other visible dirt. Strawberries, because they grow so near the ground, should not be purchased after a rain, which will spatter them with muddy drops. Only the freshest and cleanest berries should be served raw; more doubtful specimens should be cooked. By immersing them in water a few at a time and handling carefully, such fruits may be washed without much loss of flavor. These matters are also discussed in an earlier bulletin[b] of this series.

Dried figs and dates are very commonly eaten without cooking, or even washing, and yet they have been exposed for an unknown length of time to the contagion brought by dust, flies, and dirty hands. In how many houses are oranges washed before they are brought to the table, or the lemon before it is sliced for the tea or lemonade, or before the skin is grated for flavoring? Yet the skin is often very dirty.

Shelled nuts purchased in market should always be washed and scalded before they are used, as they are commonly exposed to dust, and perhaps to flies. They can afterwards be dried on a clean cloth before using.

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[a] Arch. Hyg., 41 (1901), p. 152.

[b] U. S. Dept. Agr., Farmers' Bul. 293.

Many careful housewives wash nuts in the shell before cracking, as this prevents accidental soiling of the kernels.

WASHING EGGS.

The ordinary way to break an egg is to hit it against another egg or over the edge of the mixing bowl and let the contents stream over the side of the shell without considering whether the latter is clean or not. Even if there is no visible dirt, the shell may not be as clean as it seems, for it may have come from a dirty nest or have been untidily handled. Eggs should therefore always be washed before breaking.

DISHWASHING.

The bacteriologist finds no kitchen clean enough and the ordinary methods of washing dishes he is likely to call a "smear."

Dishes have been tested to determine the number of organisms that remain on them after "ordinary" washing as compared with a method that requires an application of hot water with the help of soap or, better still, carbonate of soda, a thorough rinsing in hot water, and wiping with a sterilized cloth (that is, one which has been in boiling water since it was used before). By this latter method the dishes were practically sterile while many organisms were left on the dishes that were washed by the "ordinary" method.

One might ask what harm will they do if present. Oftentimes none, but if the bacteria are those which convey disease, dirty dishes may be the means of giving it to well persons. But most of all, persons who are at all thoughtful of such things do not want any dirt which may be prevented by good methods, simply because dirt in itself is sufficiently unpleasant.

In washing milk utensils it is first necessary to remove with warm water all traces of the milk before scalding water is used. Because of the cream adhering to the sides soap is used also, but the greatest care must be taken to remove by repeated rinsing every trace of soap. A telltale flavor of soap in the morning cream has more than once revealed careless habits in the kitchen, and made it evident that all the soap was not removed in rinsing. The utensils must then be dipped into absolutely boiling water for a moment.

It is an important matter to wash the milk bottle in which milk is now commonly delivered to customers. By this we refer to the washing of the full bottle before it is opened. It is safe to say that this is seldom done. But notice the bottle as it is brought into the kitchen, the milkman grasping it with his hand over the top. These hands perhaps more often than not have harnessed his horse, have been grasping the reins all the morning, have opened and shut doors, run along stair railings, have perhaps wiped mouth or nose, and yet the thoughtless housekeeper or cook, regarding the white cap as full security from the outer world, pours out the milk over a very dirty bottle brim. Milk bottles should be put under the hot water spigot for a moment and wiped dry with a clean cloth before opening. Most housewives agree that milk bottles should be carefully rinsed before they are returned, perhaps more from a feeling for cleanliness than for absolute necessity, as the milk bottles in all well-managed dairies are thoroughly scrubbed and washed before refilling. If such violations of this practice as recently came under observation are noted, when the driver of a dairy wagon washed out some milk bottles in a public drinking fountain provided for horses, refilled them, and disposed of them to other customers, complaint should be made to the dairy, and if this is not sufficient, to the board of health.

CARE OF THE WATER COOLER.

Water is an indispensable food adjunct and so may be properly spoken of here. The water and the ice supply should both be above suspicion. The question of wells, water, and ice supply has been discussed in earlier bulletins of this series.[a] The greatest care should be taken to keep clean and in good condition all vessels in which water is used for household purposes. Water coolers, if used, should be of some material like porcelain or enameled ware which is easily kept clean. They should be scalded out at frequent intervals. The ice, if it comes in contact with the water, should be of known quality. If such ice can not be secured, a water cooler should be used in which the ice is in a separate receptacle and does not come in contact with the water. Many families cool drinking water by putting it in the ice box in glass fruit jars or bottles. Perfect clearness is an indication of purity in ice. Cloudy ice full of bubbles or snow ice should not be used in direct contact with food, and ice which contains dirt of various kinds frozen in it should be regarded with suspicion.

If it is believed that the water is not pure, it may be boiled or filtered, or both. If filters are used, every precaution should be taken to keep them clean and in good condition and to rely only on such as really purify the water. Earthenware filters may be sterilized by placing in a pan or kettle of water and boiling them out after they have been thoroughly scrubbed with a brush. A small piece of wood should be placed under the jar to prevent direct contact with the bottom of the pan.

The water cooler in public places should always be in charge of a responsible person who will keep it clean and in good condition.

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[a] U. S. Dept. Agr., Farmers' Buls. 43, 73, 262, 309.

Some sort of a sanitary drinking fountain is desirable. The public drinking cup of the sort usually seen should not be permitted. It is uncleanly and furnishes a ready means of transmitting disease.

Recent experiments made by the Kansas State Board of Health[a] give results which are in accord with the work of other investigators and plainly showed the presence of mouth bacteria and other micro-organisms, including those which cause pneumonia, on drinking cups from an office building, a ward school, and a railroad station. This means that the user of the public drinking cup runs the risk of taking into his mouth more or less of the saliva of some other person and may take with it micro-organisms causing virulent disease as well as the ordinary mouth bacteria which are doubtless harmless. These unpleasant and dangerous features may be avoided by the use of proper drinking fountains and cups.

In many homes a glass or cup is placed by the water pail or water cooler and is used by all the members of the family. Such a custom should not be followed. Although it is necessarily less dangerous than the public drinking cup, it is not a cleanly practice and is many times without doubt responsible for the spread of colds and other minor ailments throughout a family.

PERSONAL CLEANLINESS IN THE KITCHEN.

There may sometimes be observed in the cooked dish a loss of flavor, not a bad taste, but a lack of what is appetizing. It would be interesting to know in how many cases this comes from a lack of cleanliness in utensils and methods.

Personal cleanliness is of course essential in the kitchen, and every good housekeeper endeavors to maintain a high standard in such matters. Some food manufactories make special efforts to secure cleanliness and hygienic surroundings, and the good example they set should be generally followed.

"Food and fingers are carriers of contagion." The proper way of washing the hands, if seriously taught and seriously practiced, in the market and in the kitchen, would go far to remove the source not only of infection but of such additions to the food as are disgusting to think of. In this matter some food manufactories are cleaner in their methods than are our kitchens. In one large bakery, where information was collected, the rule is in force that every employee shall wash his hands on returning to the room after leaving it for any purpose whatever.

The running tap, like the shower bath, offers a great improvement over old methods of washing. Few will have patience to fill and refill the hand basin until the hands are bathed at last in clean water, but this result is easily accomplished under the tap. The nailbrush and nail cleaner must have their place in the kitchen, and their use must be insisted on before bread or cake is mixed and after work at all soiling in character.

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[a] Bul. Kans. Bd. Health, 5 (1909), No. 3, p. 76.

Every one will admit that there is need for exercising great care in coughing and sneezing wherever such necessary acts may be annoying to others. When one recalls that experiment has shown that a fine spray of saliva may be thrown in all directions for a distance of 4 or 5 feet by a violent sneeze or cough and that often the cause of the cough or sneeze is something which can be thus communicated to others, it is evident that there is abundant reason for caution. Particularly is this essential wherever food is prepared, exposed, or served.

USE OF PAPER IN THE KITCHEN.

Paper has many uses in the kitchen. The cook needs a piece of paper on which to drain the fried croquette or fritter and she reaches out for the brown paper that came around the meat or for the grocer's bag. She turns to the same source when she wishes paper lor lining a cake pan. A little reflection will show how far from cleanly is this practice.

In every kitchen should be found a roll of grocer's paper on its frame. You are sure here of something that has not been handled since it was rolled up by machinery in the factory. Paraffin paper should also be at hand for covering food, for wrapping up sandwiches for school lunches, and for similar purposes.

IMPORTANCE OF GOOD HOUSE PLANS AND HOME CONVENIENCES.

The care of food in the home and all other forms of household work are greatly facilitated by right planning and the use of suitable materials for the construction and furnishing of the home. An adequate and convenient water supply and other conveniences are essential, not only for comfort and for saving labor, but also from the standpoint of home hygiene. The question of home conveniences, the arrangement of a kitchen, and similar topics are considered in other bulletins[a] of this series and in many volumes on the house and house construction.[b]

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[a] U. S. Dept. Agr., Farmers' Buls. 270, 317, 342.

[b] The Healthful Farmhouse. Boston, 1906. The House, Its Plan, Decoration, and Care. Isabel Bevier. Chicago, 1907.

CLEANLINESS IN PUBLIC EATING PLACES.

The sanitary condition of kitchens and the food service in hotels and other places where food is served to the public is a matter to which most persons who patronize them have given at least occasional thought.

Perhaps the most common attitude toward this subject of the "temporary home," as toward markets and other places where food is handled or prepared before it reaches the home kitchen, is that it is least disturbing to put it out of mind and to forget unpleasant things which, it is assumed, can not be remedied.

This is not the right attitude, for the subject has a direct relation to comfort and to health and is one in which public sentiment is perhaps the chief factor in securing regulation. Legislation regarding the inspection and regulation of hotels, restaurants, and other places where meals are served is in force in some cities and contemplated in others. The results of the inspection of restaurant and lunch-room kitchens in Washington, D. C., by the board of health indicates that the matter is one which needs to be under control, and concerning which the public has a right to full information, so that the clean places may be patronized and the others avoided.

Proper ventilation in hotel and restaurant kitchens, suitable sanitary conveniences for employees, and whatever else makes for clean food are matters of public hygiene which are of the same importance as is the case with bakeries, markets, candy factories, and other places where food is handled.

There are other matters which are also worth considering in this connection.

It is no very uncommon thing to notice in a hotel, restaurant, or dining car, and often in those which pride themselves on the excellence of their service, practices which would not be permitted if due attention was paid to all matters of hygiene. For instance, it may be sometimes noted that finger bowls which have not been washed since a previous service are placed before guests. Soiled napkins may also be seen occasionally in use for wiping off table dishes before service. It is certain that such practices where they exist would not continue if supervision by the management was as thorough as it should be or if patrons were not indifferent to them or lacking in observation.

The public owes a duty to the management in such matters and all such violations of the laws of hygiene and cleanliness should be reported to the proper person. Here, as in most other instances, the remedy lies in the hands of the public.

On the other hand, there is no ground for a general suspicion of the methods in use in hotels and restaurants. Probably in the majority of cases a great deal of attention is given to kitchen and serving-room equipment, which is designed as regards both material and method of construction in such a way that it may be readily kept clean, and good hotels and restaurants are constantly endeavoring to make sure that food is handled, cooked, and served in a cleanly manner. In general, carefully managed hotels welcome inspection of their kitchens and storerooms by visitors.

In conclusion it may be said that the preparation of food must more and more come to be considered as an occupation that requires of the person who undertakes it knowledge and habits quite beyond what is now expected of a person who is simply a "good cook."

It is even more essential that the housewife who buys food and who attends to her own food preparation should have such knowledge.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to any **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals.
24. Hog Cholera and Swine Plague.
27. Flax for Seed and Fiber.
28. Weeds: And How to Kill Them.
30. Grape Diseases on the Pacific Coast.
32. Silos and Silage.
33. Peach Growing for Market.
34. Meats: Composition and Cooking.
35. Potato Culture.
36. Cotton Seed and Its Products.
42. Facts About Milk.
44. Commercial Fertilizers.
47. Insects Affecting the Cotton Plant.
48. The Manuring of Cotton.
49. Sheep Feeding.
51. Standard Varieties of Chickens.
52. The Sugar Beet.
54. Some Common Birds.
55. The Dairy Herd.
56. Experiment Station Work—I.
59. Bee Keeping.
60. Methods of Curing Tobacco.
61. Asparagus Culture.
62. Marketing Farm Produce.
63. Care of Milk on the Farm.
64. Ducks and Geese.
65. Experiment Station Work—II.
69. Experiment Station Work—III.
71. Essentials in Beef Production.
73. Experiment Station Work—IV.
77. The Liming of Soils.
78. Experiment Station Work—V.
79. Experiment Station Work—VI.
81. Corn Culture in the South.
82. The Culture of Tobacco.
83. Tobacco Soils.
84. Experiment Station Work—VII.
85. Fish as Food.
86. Thirty Poisonous Plants.
87. Experiment Station Work—VIII.
88. Alkali Lands.
91. Potato Diseases and Treatment.
92. Experiment Station Work—IX.
93. Sugar as Food.
96. Raising Sheep for Mutton.
97. Experiment Station Work—X.
98. Suggestions to Southern Farmers.
99. Insect Enemies of Shade Trees.
100. Hog Raising in the South.
101. Millets.
103. Experiment Station Work—XI.
104. Notes on Frost.
105. Experiment Station Work—XII.
106. Breeds of Dairy Cattle.
107. Experiment Station Work—XIII.
110. Rice Culture in the United States.
112. Bread and Bread Making.
113. The Apple and How to Grow It.
114. Experiment Station Work—XIV.
118. Grape Growing in the South.
119. Experiment Station Work—XV.
120. Insects Affecting Tobacco.
121. Beans, Peas, and Other Legumes as Food.
122. Experiment Station Work—XVI.
124. Experiment Station Work—XVII.
126. Practical Suggestions for Farm Buildings.
127. Important Insecticides.
128. Eggs and Their Uses as Food.
131. Household Tests for Detection of Oleomargarine and Renovated Butter.
132. Insect Enemies of Growing Wheat.
133. Experiment Station Work—XVIII.
134. Tree Planting on Rural School Grounds.
135. Sorghum Sirup Manufacture.
137. The Angora Goat.
138. Irrigation in Field and Garden.
139. Emmer: A Grain for the Semiarid Regions.
140. Pineapple Growing.
142. Principles of Nutrition and Nutritive Value of Food.
144. Experiment Station Work—XIX.
145. Carbon Bisulphid as an Insecticide.
149. Experiment Station Work—XX.
150. Clearing New Land.
152. Scabies of Cattle.
154. Home Fruit Garden: Preparation and Care.
155. How Insects Affect Health in Rural Districts.
156. The Home Vineyard.
157. The Propagation of Plants.
158. How to Build Small Irrigation Ditches.
162. Experiment Station Work—XXI.
164. Rape as a Forage Crop.
165. Silkworm Culture.
166. Cheese Making on the Farm.
167. Cassava.
169. Experiment Station Work—XXII.
170. Principles of Horse Feeding.
172. Scale Insects and Mites on Citrus Trees.
173. Primer of Forestry. Part I: The Forest.
174. Broom Corn.
175. Home Manufacture and Use of Unfermented Grape Juice.
176. Cranberry Culture.
177. Squab Raising.
178. Insects Injurious in Cranberry Culture.
179. Horseshoeing.
181. Pruning.
182. Poultry as Food.
183. Meat on the Farm: Butchering, Curing, and Keeping.
185. Beautifying the Home Grounds.
186. Experiment Station Work—XXIII.
187. Drainage of Farm Lands.
188. Weeds Used in Medicine.
190. Experiment Station Work—XXIV.
192. Barnyard Manure.
193. Experiment Station Work—XXV.
194. Alfalfa Seed.
195. Annual Flowering Plants.
196. Usefulness of the American Toad.
197. Importation of Game Birds and Eggs for Propagation.
198. Strawberries.
199. Corn Growing.
200. Turkeys.
201. Cream Separator on Western Farms.
202. Experiment Station Work—XXVI.
203. Canned Fruits, Preserves, and Jellies.
204. The Cultivation of Mushrooms.
205. Pig Management.
206. Milk Fever and Its Treatment.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries.
210. Experiment Station Work—XXVII.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil.
213. Raspberries.
217. Essential Steps in Securing an Early Crop of Cotton.
218. The School Garden.
219. Lessons from the Grain Rust Epidemic of 1904.
220. Tomatoes.
221. Fungous Diseases of the Cranberry.
222. Experiment Station Work—XXVIII.
223. Miscellaneous Cotton Insects in Texas.
224. Canadian Field Peas.
225. Experiment Station Work—XXIX.
227. Experiment Station Work—XXX.
228. Forest Planting and Farm Management.
229. The Production of Good Seed Corn.

231. Spraying for Cucumber and Melon Diseases.
232. Okra: Its Culture and Uses.
233. Experiment Station Work—XXXI.
234. The Guinea Fowl.
235. Preparation of Cement Concrete.
236. Incubation and Incubators.
237. Experiment Station Work—XXXII.
238. Citrus Fruit Growing in the Gulf States.
239. The Corrosion of Fence Wire.
241. Butter Making on the Farm.
242. An Example of Model Farming.
243. Fungicides and Their Use in Preventing Diseases of Fruits.
244. Experiment Station Work—XXXIII.
245. Renovation of Worn-out Soils.
246. Saccharine Sorghums for Forage.
248. The Lawn.
249. Cereal Breakfast Foods.
250. The Prevention of Whea Smut and Loose Smut of Oats.
251. Experiment Station Work– XXXIV.
252. Maple Sugar and Sirup.
253. The Germination of Seed Corn.
254. Cucumbers.
255. The Home Vegetable Garden.
256. Preparation of Vegetables for the Table.
257. Soil Fertility.
258. Texas or Tick Fever and Its Prevention.
259. Experiment Station Work—XXXV.
260. Seed of Red Clover and Its Impurities.
262. Experiment Station Work—XXXVI.
263. Practical Information for Beginners in Irrigation.
264. The Brown-tail Moth and How to Control It.
266. Management of Soils to Conserve Moisture.
267. Experiment Station Work—XXXVII.
268. Industrial Alcohol: Sources and Manufacture.
269. Industrial Alcohol: Uses and Statistics.
270. Modern Conveniences for the Farm Home.
271. Forage Crop Practices in Western Oregon and Western Washington.
272. A Successful Hog and Seed-corn Farm.
273. Experiment Station Work—XXXVIII.
274. Flax Culture.
275. The Gipsy Moth and How to Control It.
276. Experiment Station Work—XXXIX.
277. The Use of Alcohol and Gasoline in Farm Engines.
278. Leguminous Crops for Green Manuring.
279. A Method of Eradicating Johnson Grass.
280. A Profitable Tenant Dairy Farm.
281. Experiment Station Work—XL.
282. Celery.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains.
285. Advantage of Planting Heavy Cotton Seed.
286. Comparative Value of Whole Cotton Seed and Cotton-seed Meal in Fertilizing Cotton.
287. Poultry Management.
288. Nonsaccharine Sorghums.
289. Beans.
290. The Cotton Bollworm.
291. Evaporation of Apples.
292. Cost of Filling Silos.
293. Use of Fruit as Food.
294. Farm Practice in the Columbia Basin Uplands.
295. Potatoes and Other Root Crops as Food.
296. Experiment Station Work—XLI.
298. Food Value of Corn and Corn Products.
299. Diversified Farming Under the Plantation System.
300. Some Important Grasses and Forage Plants for the Gulf Coast Region.
301. Home-grown Tea.
302. Sea-Island Cotton: Its Culture, Improvement, and Diseases.
303. Corn Harvesting Machinery.
304. Growing and Curing Hops.
305. Experiment Station Work—XLII.
306. Dodder in Relation to Farm Seeds.
307. Roselle: Its Culture and Uses.
309. Experiment Station Work—XLIII.
310. A Successful Alabama Diversification Farm.
311. Sand-clay and Burnt-clay Roads.
312. A Successful Southern Hay Farm.
313. Harvesting and Storing Corn.
314. A Method of Breeding Early Cotton to Escape Boll-weevil Damage.
315. Progress in Legume Inoculation.
316. Experiment Station Work—XLIV.
317. Experiment Station Work—XLV.
318. Cowpeas.
319. Demonstration Work in Cooperation with Southern Farmers.
320. Experiment Station Work—XLVI.
321. The Use of the Split-log Drag on Earth Roads.
322. Milo as a Dry-land Grain Crop.
323. Clover Farming on the Sandy Jack-pine Lands of the North.
324. Sweet Potatoes.
325. Small Farms in the Corn Belt.
326. Building up a Run-down Cotton Plantation.
328. Silver Fox Farming.
329. Experiment Station Work—XLVII.
330. Deer Farming in the United States.
331. Forage Crops for Hogs in Kansas and Oklahoma.
332. Nuts and Their Uses as Food.
333. Cotton Wilt.
334. Experiment Station Work—XLVIII.
335. Harmful and Beneficial Mammals of the Arid Interior.
336. Game Laws for 1908.
337. Cropping Systems for New England Dairy Farms.
338. Macadam Roads.
339. Alfalfa.
341. The Basket Willow.
342. Experiment Station Work—XLIX.
343. The Cultivation of Tobacco in Kentucky and Tennessee.
344. The Boll Weevil Problem with Special Reference to Means of Reducing Damage.
345. Some Common Disinfectants.
346. The Computation of Rations for Farm Animals by the Use of Energy Values.
347. The Repair of Farm Equipment.
348. Bacteria in Milk.
349. The Dairy Industry in the South.
350. The Dehorning of Cattle.
351. The Tuberculin Test of Cattle for Tuberculosis.
352. The Nevada Mouse Plague of 1907-8.
353. Experiment Station Work—L.
354. Onion Culture.
355. A Successful Poultry and Dairy Farm.
356. Peanuts.
357. Methods of Poultry Managements at the Maine Agricultural Experiment Station.
358. A Primer of Forestry. Part II: Practical Forestry.
359. Canning Vegetables in the Home.
360. Experiment Station Work—LI.
361. Meadow Fescue: Its Culture and Uses.
362. Conditions Affecting the Value of Market Hay.
363. The Use of Milk as Food.
364. A Profitable Cotton Farm.
365. Potato Growing in Northern Sections.
366. Experiment Station Work—LII.
367. Lightning and Lightning Conductors.
368. The Eradiction of Bindweed, or Wild Morning-Glory.
369. How to Destroy Rats.
370. Replanning a Farm for Profit.
371. Drainage of Irrigated Lands.
372. Soy Beans.
373. Irrigation of Alfalfa.
374. Experiment Station Work—LIII.
375. Care of Food in the Home.
376. Game Laws for 1909.
377. Harmfulness of Headache Mixtures.

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INDEX.

	Farmers' Bulletin No.	Page.
Abel, Mary Hinman, bulletin on "Care of food in the home"	375	1–46
Abortion, contagious, of cattle	374	19–22
Acid phosphate, use on soy beans, directions	372	20
Adulteration, milk, methods	363	14
Alfalfa, destruction by field mice	352	5–7
effect of rise of ground water	373	44–45
fields, subirrigation	373	35–38
green, bait for poisoning field mice, management	352	17
growing on new land, preparatory crop, suggestions	373	12–13
soils and conditions suitable	373	8–10
hay, bait for poisoning field mice, management	352	14–17
growing, effect on bindweed	368	14
nutritive content	362	17
importance to western farmers, yield, etc	373	7–8
inoculation for, and use of lime	374	5–7
irrigated, profit to grower, tables, etc	373	47–48
irrigation	373	1–48
water requirements	373	38–39
losses from mouse plague	352	9
pasturing irrigated fields	373	46–47
seed, dodder-infested	353	7–9
production under irrigation	373	47
winter conditions and management	373	41–42
Alkali, effect on cement structures	353	20–21
origin and composition	371	45–46
Allium cepa. *See* Onion.		
Alsike clover hay, nutritive content	362	17
Ant, mound-building, description, habits, harmfulness, etc	353	15–17
destruction, method	353	16–17
mounds, prairie, description, injury to harvesting machinery	353	15–16
Arachis hypogea. *See* Peanut.		
Arid regions, native hays, nutritive value	374	12–16
Arsenic, use against rats, suggestions	369	15
Asparagus, canning, directions	359	14
Atriplex argentea, nutritive value, experiments	374	15–16
Auger, soil, description	373	9
Bacteria, food, causes, control measures, etc	375	7–11
milk, nature, and effects	363	11–12
nature, vitality, etc	359	6–7
use against rats, remarks	369	18
Bait, rat, recommendations	369	11
Baits, mouse, discussion	352	14–17
Bakeries, sanitation, importance	375	21–22
Barium carbonate, use against rats, suggestions	369	14–15
Barley, use as silage without silo	355	11
soiling crop	355	16
Barn, dairy, requirements for clean milk	366	25
Barnett, E., and A. F. Conradi, investigations of hook-worm disease of cattle	366	17–19
Barrel trap for rats, description	369	12–13
"Barreling" onions, curing method	354	22
Beans, Lima, canning, directions	359	14
soy. *See* Soy beans.		
string, canning, directions	359	12

	Farmers' Bulletin No.	Page.
Beattie, W. R., bulletin on "Onion culture"	354	1–36
"Peanuts"	356	1–40
Beef cattle, long feeding compared with short feeding, experiments	374	17–19
scrap, use as chicken feed	357	16
Beets, canning, directions	359	13
Bermuda grass, uses, eradication, etc	374	16–17
onion. *See* Onions, Bermuda.		
Bindweed, California, description	368	8–9
distribution, habits of growth, etc	368	7–8
eradication	368	1–19
field, description	368	8
hedge, description	368	8
injurious effects	368	5–7
underground characters	368	9–10
Birds, destruction by poisons set for field mice	352	7–8
enemies of field mice	352	21–22
rats	369	9
Biscuits, baking powder, flour suitable, experiments	374	31–32
Black rat. *See* Rat.		
Blackbird, crow, food	374	30–31
Blair, A. W., study of muck soils, conclusions	366	5–6
Blanchard, H. L., management of poultry and dairy farm	355	1–40
Bordeaux mixture, use as spray for potatoes	365	11–12, 17, 19–20
Bovine uncinariasis. *See* Hook-worm, disease of cattle.		
Brassica oleracea, feed for dairy cows, value, etc	360	30–31
Bread, cooling, storing, etc	375	35–36
skim milk, food value	363	35
"Break joint," sheep, sign of age in grading for market	360	21–22
Breazeale, J. F., bulletin on "Canning vegetables in the home"	359	1–16
Breeding, corn, ten generations	366	10–13
stock, chickens, selection	357	5–6
Bridge grafting, remedy for girdled trees	360	13–14
Brooder houses, descriptions	357	10–13
Brooders, management	355	26–27
Brown, Charles F., bulletin on "Drainage of irrigated lands"	371	1–52
Brown rat. *See* Rat.		
Brush, clearing land for irrigation, directions	373	10–11
Bucks, breeding, market classes and grades	360	27
sheep, market classes, note	360	24
Buildings, cement, effect of alkali	353	20–21
farm, lightning rods	367	14–20
foundations, treatment of cement and sandstone to prevent disintegration from alkali	353	22
metal roof, protection from lightning	367	18–20
rat-proof, construction	369	6–8
storehouse for onions, construction	354	24–27
Bulls, dairy farm, management	355	14, 18
Burrows, mouse, obliterating methods	352	18
Butter, composition and fuel value	363	36–38
cooking, treatment	375	38
marketing, prices, etc., West Washington dairy farm	355	19–20
rendered, manufacture, uses, etc	363	37
sweet, making, uses, etc	363	37
Buttermilk, forms, uses, etc	363	40
By-products, peanut, uses	356	33–34

Cage trap for rats, description	369	11–12
Calves, dairy farm, rearing	355	18–19
Candy, peanut, directions for making	356	32
Canned goods, storage, suggestions	375	36
Canning vegetables, caution	359	16
in the home	359	1–16
Carbohydrates, milk, nature, percentage, etc	363	11
Carbon bisulphid, remedy for mound-building prairie ant	353	16–17

	Farmers' Bulletin No.	Page.
Carbon bisulphid, use against peanut insects	356	38
rats, directions	369	17
Carmichael, B. E., experiments, as to relative value of corn and oats for work horses	374	24–26
Carnations, bursting, causes, remedies, etc	360	7–8
Carrots, canning, directions	359	14
Catch crop, peanuts, value	356	35–36
Cattle, beef, long feeding compared with short feeding, experiments	374	17–19
contagious abortion	374	19–22
hook-worm disease	366	17–19
loss from tuberculosis	351	2
tuberculosis, diagnosis	351	2
prevalence	351	2
tuberculin test	351	1–8
Cauliflower, canning, directions	359	14
Cellar, home, requirements	375	27–28
Cement structures, effect of alkali	353	20–21
Cercospora personata, leaf-spot of peanut, description, remedy, etc	356	39
"Certified" milk, definition and value	363	19
value, etc., comparison with other market milk	366	26–27
Charlock, eradication by spraying, directions	360	16
Check box, use in preparing land for irrigation, description	373	29
Cheese, composition and nutritive value	363	37–38
cottage, preparation and uses	363	38–39
making, coagulation of milk, effects of glass, metals, etc	353	17–19
Chicago, milk supply, methods, conditions	366	21–22
Chickens, Black Minorca, management for egg production	355	33–39
breeding for egg production	355	33–39
stock, selection, suggestions	357	5–6
Brown Leghorn, management for egg production	355	33–39
classes for market	355	39
fattening, amount of grain required to produce one pound of flesh	357	20
for market	357	19–20
feeding, requirements for one hen for year	357	33
killing for market, method	353	12
males and culls, management, disposal, etc	355	29–30
selection	355	38–39
Plymouth Rock, management for egg production	355	33–39
raising by hens, suggestions	357	6–8
with incubator	357	8–17
range and feeding	357	17–19
Chicks, brooder house, treatment	357	13–17
feeding	255	28–29
methods	357	13–17
management in brooder	355	26–29
Cities, milk supply	366	20–28
Citrus culture, Southern Texas	374	7–11
trifoliata, value as stock for citrus fruit growing in Texas	374	9
Clabber, uses, value, etc	363	40–41
"Clarified milk," application of term	363	20
Clearfield drainage experiment, Utah, results, etc	371	22–24
Climate, relation of forests	358	29–36
"Clotted cream," preparation and uses	363	39
Clover, growing for seed, rotation with potato crop	365	25–26
hay, alsike and red, nutritive content	362	17
fertilizing content	362	14
value	362	27
seed, commercial, adulteration, vitality, etc	353	5–7
light compared with heavy, number per pound, etc	353	5
purity, importance	353	6
use with meadow fescue for pasture	361	9
value in rotation on potato farm	365	14–15
Clover-seed farming, possibilities, suggestions, etc	370	13–15
Coal-tar preparations, use against chicken mites	355	24

	Farmers' Bulletin No.	Page.
Cockerels, feeding for market	357	19–20
treatment, disposal, etc	355	30, 38–39
Cole, L. J., remarks on the crow as a menace to poultry raising	366	28–29
Concrete buildings, effect of alkali	353	20–21
use in rat-proof buildings	369	6–8
Condensed milk, preparation, uses, etc	363	18–19
Conductors, lightning, and nonconductors	367	8
copper, and iron, comparison	367	14, 15
Conradi, A. F., and E. Barnett, investigation of hook-worm disease of cattle	366	17–19
Convolvulus arvensis. *See* Bindweed, field.		
californicus. *See* Bindweed, California.		
sepium repens, description	368	8
See also Bindweed, hedge.		
Cooking, use of milk	363	35
Coop, for hen and brood, suggestions	357	7
Cooper, T. P., and E. C. Parker, investigations of farm labor in Minnesota	366	30–32
Copper sulphate, remedy for wild mustard	360	16
use in spraying potato crop	365	11–12
Coppice, simple and stored, management	358	9–12
Corn and soy beans, mixed crop, management	372	17
breeding, ten generations	366	10–13
canning, directions	359	11–12
feed for work horses, experiments	374	24–26
growing on South Carolina cotton farm	364	14–15
height of ears on stalk, results of six generations of breeding	366	11–12
hills, distance apart, effect on yield, etc	360	5–7
hulled, composition, digestibility, etc	360	31–32
inclination of ear to stalk, five generations of breeding, results	366	12–13
kernels to hill, proper number	360	5–7
pork, production	370	23
protein and oil content, results of ten generations of breeding	366	10–11
Corvus brachyrhynchos. *See* Crow.		
Cottage cheese, preparation, and uses	363	38–39
Cotton farm, profitable	364	1–23
equipment	364	18
varieties on South Carolina cotton farm	364	13
Cotton-seed meal, feeding value, comparison with soy beans	372	23–24
Cover crops, citrus fruit culture, Texas, suggestions	374	10
winter, for South Carolina cotton farm	364	21
Cowpea hay, nutritive content	362	17
Cowpeas and soy beans, mixed crop for hay, management, value, etc.	372	16–17
comparison with soy beans	372	24–25
growing on South Carolina cotton farm	364	17
Cows, abortion, contagious	374	19–22
dairy, feeding, management, etc	370	28–29
value of soy beans, experiments	372	21
winter and summer	355	15–17
management for clean milk	366	25
on West Washington farm	355	12–19
drying and freshening, management	355	17–18
effect of machine milking	366	19–20
feed, vetch hay and silage	360	29–30
Cox, H. R., bulletin on "The eradication of bindweed or wild morning-glory"	368	1–19
Cream, digestibility	363	39
evaporated, preparation, uses, etc	363	18
whipping quality, discussion and suggestion	363	39
Cresol, disinfectant and insecticide for poultry	357	34–36
soap, making, directions, value as disinfectant, etc	357	35–36
use as disinfectant and insecticide for poultry	357	34–36
Cresolis compositus, liquor, use as disinfectant for poultry	357	34–36
Crib, rat-proof, construction	369	8
Crop rotation, cotton farm	364	8–9
dairy farm	370	31

Farmers' Bulletin No. Page.

Crop rotation, for hay lands, importance of legumes ... 362 ... 15
  grain and clover farms ... 370 ... 14–17
    hay farm ... 370 ... 10–12
  hog farm ... 370 ... 23–26
  onion culture ... 354 ... 9
  peanut culture, suggestions ... 356 ... 11–13
  potato growing, Maine ... 365 ... 8
  sheep farm ... 370 ... 21–22
  value of meadow fescue ... 361 ... 13–14
    soy beans ... 372 ... 20
Crops, injury by bindweed ... 368 ... 5–7
  Nevada, losses from mouse plague ... 352 ... 9–10
  silage, West Washington ... 355 ... 11–12
  smothering, use in eradication of bindweed ... 363 ... 13–14, 17
Crow blackbird, food ... 374 ... 30–31
  danger to poultry ... 366 ... 28–29
  food requirements ... 366 ... 28–29
Crows, destruction of eggs and poultry, preventive measures, suggestions ... 366 ... 29
Curing onions for storing ... 354 ... 22
  peanuts, directions ... 356 ... 20–22
Cuti tuberculin test, nature, results, etc ... 351 ... 4
Cutworms, damage to onion crop ... 354 ... 35

Dairy and poultry farm, successful ... 355 ... 1–40
    West Washington, income ... 355 ... 20, 40
  barn, requirements for clean milk ... 366 ... 25
  cows, feed, kale ... 360 ... 30–31
    vetch hay and silage ... 360 ... 29–30
    feeding, value of soy beans, experiments ... 372 ... 21
  farm, ice box, construction, materials, etc ... 353 ... 29–31
    management, returns, etc ... 370 ... 27–33
  herd, management on west Washington dairy farm ... 355 ... 12–19
  products, west Washington dairy farm, disposal, prices, etc ... 355 ... 19–20
"Devonshire clotted cream," preparation and uses ... 363 ... 39
Dielectric, definition ... 367 ... 9
Digestion, processes ... 363 ... 21–23
Dishwashing, care, importance, etc ... 375 ... 41–42
Disinfectants, poultry house, preparation, application, etc ... 357 ... 34–36
    use in poultry raising ... 355 ... 24, 29, 37
Ditches, irrigation, construction ... 373 ... 31–35
Dodder, description, harmfulness, etc ... 353 ... 6–9
  eradication by iron sulphate solution ... 360 ... 17
  in alfalfa seed ... 353 ... 7–9
DODGE, LAWRENCE G., bulletin on "Farm management in northern potato-growing sections" ... 365 ... 1–31
Dogs, injury to sheep, note ... 374 ... 24
  value as ratters, note ... 369 ... 16
    in destruction of field mice ... 352 ... 20
Dough, mixing with fat, methods ... 360 ... 32
Downy mildew, onions, description, remedies, etc ... 354 ... 34–35
Drag, brush for obliterating mouse burrows ... 352 ... 18
Drainage, irrigated lands, field construction ... 371 ... 49–50
    preliminary considerations, etc ... 371 ... 47–49
  methods for several conditions ... 371 ... 44
  of irrigated lands ... 371 ... 1–52
  peaty soil, Washington dairy and poultry farm ... 355 ... 8
  preliminary determinations ... 371 ... 47
  surface, treatment of worn-out cotton farm ... 364 ... 10
Drained lands, care, treatment, etc ... 371 ... 51
Drains, obstruction by roots, danger ... 371 ... 11
Drawing poultry for market, directions ... 353 ... 13–14
Driveways, clearing of weeds ... 360 ... 15
Dry regions, growing potatoes under straw, suggestions ... 353 ... 9–10
Dugat orange, hardiness, experiments ... 374 ... 8
Dust, composition, relation to impure foods, caution, etc ... 375 ... 17–18

	Farmers' Bulletin No.	Page.
Eggplant, canning, directions	359	13
Eggs, classes for market	355	39
infertile from incubator, use as chicken feed	355	26
use as chicken feed	357	14
keeping quality, effect of season, environment, etc	353	14–15
preservation, selection, care, etc	353	14–15
washing, importance, note	375	41
"Electrical field," use of term	367	9
"potential," use of term	367	9–10
Electricity, origin	367	8
Electrification, positive and negative	367	8–11
English bluegrass. *See* Fescue, meadow.		
Ensilage, soy beans, value, remarks	372	18
Ewes, breeding, market classes and grades	360	27
care at lambing time, prevention of losses	374	22–24
feeder, classes and grades	360	26–27
feeding before lambing, suggestions	374	23
management on sheep farm	370	19–23
market classes	360	23–24
Experiment Station Work—L	353	1–32
LI	360	1–32
LII	366	1–32
LIII	374	1–32
Farm buildings, lightning rods	357	14–20
cotton, profitable	364	1–23
dairy and poultry, cropping system	355	9–11
ditches, irrigated lands, construction	373	31–35
management in northern potato-growing sections	365	1–31
poultry and dairy, successful	355	1–40
power laundry	353	31–32
produce, consumption per man, Minnesota farms	366	31
replanning for profit	370	1–36
Farms, poor returns, causes	370	35
six types, incomes, table	370	33–34
management, results, etc	270	10–35
Fat, mixing into dough, methods	360	32
rendering for cooking purposes, recipes	375	37–38
Fats, care and utilization in the home	375	37–38
milk, nature, percentage, etc	363	11
Feed, chicken, amount of grain to produce 1 pound of flesh	357	20
cow, vetch hay and silage	360	29–30
peanuts, varieties used	356	31
value of soy beans compared to other feeds	372	20–22
Feeder sheep, classes and grades	360	24–27
Feeding beef cattle, short-fed compared with long-fed, experiments	374	17–19
chickens	355 357	28–29, 35–36 13–20
dairy cows, winter and summer	355	15–17
stuffs, danger from weed seeds	366	16–17
trough, chicken, description	357	18–19
work horses, experiments	374	24–26
Fences, dog-proof, directions for building, cost, etc	374	24
wire, danger from lightning, prevention	367	13
Ferrets, use against rats, remarks	369	17
Fertilizer for soy beans, use of acid phosphate	372	20
Fertilizers, commercial, use in onion culture	354	12–13
cotton, on worn-out cotton farms	364	13, 19–20
for timothy hay	366	6–10
onion culture	354	11–13
peanut culture	356	12–13
relation to yield on South Carolina cotton farm	364	19–20
Fertilizing elements in hay	362	14–15
Fescue, meadow, culture and uses	361	1–22
effect on soil	361	14
enemies	361	14–16

	Farmers' Bulletin No.	Page.
Fescue, meadow, experiments in East, results	361	16–17
history, description, value, etc	361	8
importance, present and future	361	18
yield, comparison with other grasses	361	17
tall, habits, yield, etc	361	19–21
rust resistance, importance, etc	361	20–21
Festuca elatior. *See* Fescue, meadow; Fescue, tall.		
pratensis. *See* Fescue, meadow.		
Fish, quality, importance	375	24
Flavor, milk, influences	363	14
Flies, house, carriers of disease, suggestions, etc	375	14–17
Flooding land, winter, use in destroying field mice	352	19
Floods, causes	358	38–40
Flour, biscuit, experiments with strong wheat flour and soft wheat flour	374	31–32
storage, suggestions	375	34–35
Flumes, use in logging	358	28
Food, care in the home	375	1–46
farm laborer, Minnesota, daily and annual consumption per man	366	31
infants', use of milk	363	24, 25–27
soy beans, use in foreign countries	372	5
storage methods	375	26–32
supply, effect of pure-food law, remarks	375	19–20
use of milk	363	1–44
Foods, raw, danger	375	13–14
Forage crop, peanuts, value	356	35, 36
soy beans, value, extent, etc	372	5–6
peanut, handling, curing, etc	356	37–38
plants, native of arid regions, nutritive value	374	12–16
Forest management	358	3–29
reserves, history, extent, etc	358	46–48
yield, methods of determination	358	7–8
Forestry, early and modern	358	41–42
foreign and American	358	40–48
practical	358	1–48
primer, Part 2, Practical forestry	358	1–48
State, note	358	48
Forests, relation to climate	358	29–36
requirements for best service	358	6–7
seed, management	358	12–15
United States, extent, history, etc	358	44–46
Formaldehyde treatment for potato scab	365	17
FORTIER, SAMUEL, bulletin on "Irrigation of alfalfa"	373	1–48
Fowls, marketing, killing, dressing, etc	353	12–14
France, forestry schools, conditions, etc	358	42–43
Freezes, protection of citrus trees, Texas	374	10–11
FROLEY, J. W., and C. BEAMAN SMITH, bulletin on "Replanning a farm for profit"	370	1–36
Fruits, keeping, suggestions	375	33–34
washing, care	375	40–41
Fumigation, destruction of mound-building prairie ant	353	16–17
for potato scab, management	365	17
use against rats, directions	369	17–18
Furrower, use in preparing land for irrigation, description	373	29
Garbage, relation to rat pests	369	8–9
Garland drainage experiment, Utah, cost, results, etc	371	12–15
Garlic, description, note	354	30
Gases, use in rat destruction	369	17–18
Gates, irrigation ditch, description	373	32
Germany, forestry, schools, conditions, etc	358	42
Germicide, cresol soap, value, manufacture, etc	357	35–36
"Ghee," preparation, uses, etc	375	38
(rendered butter) manufacture, uses, etc	363	37
"Goober pea." *See* Peanut.		

	Farmers' Bulletin No.	Page.
Goodrich, C. L., bulletin on "A profitable cotton farm"	364	1–23
Gopher vine. *See* Bindweed.		
Graded milk, importance, suggestions	363	19
Grader, use in preparing land for irrigation, and description	373	18–19
Grading onions, methods	354	28
Grafting, bridge, remedy for girdled trees	360	13–14
Graham, C. K., directions for preparing fowls for market	353	12–14
Grain, chicken feed, amount required to produce 1 pound of flesh	357	20
Grape fruit, growing, Texas, experiments	374	8
Grapes, pruning	374	11–12
Grass, Bermuda, uses, eradication, etc	374	16–17
lands, native, preparation for irrigation	373	12
top-dressing	366	6–10
Grasses, mixtures for pasture, value of meadow fescue	361	13
native of arid regions, nutritive value	374	12–16
Groceries, storage, suggestions	375	34–36
"Ground pea." *See* Peanut.		
"Groundnut." *See* Peanut.		
Groundwater, rise, effect on alfalfa	373	44–45
Grubber, sagebrush, description	373	11
Guillotine trap for rats, description	369	10–11
Gumbo, canning, directions	359	13
Harrow, disk, use in onion culture	354	10–11
Harrowing, potato cultivation, importance	365	15
Harvesting Bermuda onions	354	31
onion crop, methods	354	21–24
peanut crop, methods	356	19–22
potato crop, methods in Maine	365	12–13
soiling crops, west Washington dairy farm	355	17
soy beans	372	19
Hawks, enemies of field mice	352	21–22
Hay areas, United States	362	9
aroma, conditions affecting	362	19
choice, maximum of weeds and other grasses	362	19–20
crop, percentage by States	362	9–10
rotation, suggestions for New York	366	8
digestibility, conditions affecting	362	18–19
grades adopted by the National Hay Association	362	23–25
industry, factors	362	7–8
lands, increase in value by States, table	362	13–14
need of rotations with leguminous crops	362	15
low grade, causes	362	8, 20–21
value, remedy, etc	362	21–23
market, conditions affecting	362	1–29
meadow fescue, value	361	12
palatability, conditions affecting	362	18
peanut, feed value	356	36
poisoned, remedy for field mice	352	8–9, 10
potato farm in Maine, question	365	22–23
prices for forty years	362	13
soy bean and cowpea, mixture in growing, value, management, etc	372	16–17
cutting, curing, etc	372	14–15
note	372	6
stacking, losses	362	25–27
timothy, manures suitable	366	6–10
trade, southern, demands, etc	362	9
vetch, and vetch silage for cows	360	29–30
yield affected by mice	352	5
per acre, increase from 1865 to 1905	362	10–13
Hays, fertilizing contents of different kinds	362	14–15
native of arid regions, nutritive value	374	12–16
nutritive substances, table, etc	362	16–17
Hays, Willet M., investigations of farm labor in Minnesota	366	30, 31

	Farmers' Bulletin No.	Page.
Heifers, dairy herd, suggestions	365	19
Hen house. *See* Poultry houses.		
with brood, management	357	7–8
HENRY, ALFRED J., bulletin on "Lightning and lightning conductors"	366	1–20
Hens, age for breeders	355	32
broody, management	355	35–36
care, effect on keeping quality of eggs	353	14
compared with incubators, experiments	353	10–12
feeding, amount per bird per year	357	33
layers and breeders, selection	355	31–32
laying, care and management	355	35–36
sitting, management	357	6–7
Hog farm, management, returns, etc	370	23–27
feeding value of corn, pork production	370	23
Hogs, fattening, use of peanuts	356	37
feeding, value of peanuts	356	33
soy beans, experiments	372	22
management, marketing, etc., on Washington dairy farm	355	19–20
soy bean pasturage, value, management, etc	372	15–16
use in eradication of bindweed	368	14–16
Home canning, vegetables	359	1–16
care of food	375	1–46
Hominy, composition, digestibility, etc	360	31–32
Hook, poultry, for holding fowls for plucking	353	13–14
Hook-worm, cattle, eradication, etc., suggestions	366	18–19
disease of cattle	366	17–19
Horses, raising on potato farm	365	24
work, feeding, experiments	374	25–26
House flies, carriers of disease germs, suggestions, etc	375	14–17
rat. *See* Rat.		
Houses, potato, construction	365	13–14
poultry, construction, various kinds, etc	357	20–31
description, cost, etc	355	21–23
protection from lightning	367	13–20
Huntington drainage experiment, Utah, cost, results, etc	371	26–32
Hyde Park drainage experiment, Utah, cost, results, etc	371	7–11
Hydrocyanic-acid gas, use against rats, caution, etc	369	17
"Hygienic" milk, application of term	363	19

◆

	Farmers' Bulletin No.	Page.
Ice box, cheap and efficient, for dairy farm	353	29–31
chests, description, care, etc	375	29–30
machine, home, use, etc	375	29
Implements, eradication of bindweed	368	12–13
for preparing land for irrigation	373	14–15, 17, 19, 21, 22–23, 26, 29, 33, 34
onion culture, description, value, etc	354	10–11, 17, 19
peanut culture, description	356	10, 11, 16, 17, 18, 19–21
potato growing, description	365	10–11, 13
Inbreeding, chickens, results	355	33
Incubation, moisture requirements	357	9–10
poultry farm in west Washington	355	25–26
Incubator room, arrangement, management, etc	357	9–10
west Washington poultry farm, arrangement, etc	355	25
Incubators compared with hens, experiments	353	10–12
management	355 357	25–26 8–9
Indemnity, tuberculous animals, suggestions	351	7
India, British, forestry, history, and conditions	358	44
Infant foods	363	24, 25–26
Inoculation for alfalfa	374	5–7
soy beans, methods	372	13–14

	Farmers' Bulletin No.	Page.
Insecticide, poultry, use of cresol and compounds	357	34-36
Insects injurious to peanuts	356	38
Insulators, lightning	367	8
Iron sulphate, remedy for wild mustard	360	16
Irrigated lands, abandoned and unprofitable, area	371	5
drainage	371	1-52
needing drainage, classes	371	45
Irrigation, alfalfa	373	1-46
methods	373	13-31
border method	373	13-16
check method, description	373	16-20
conditions suitable	373	9-10
flooding method, description	373	20-25
furrow method, description	373	25-35
onion culture, management	354	20-21
use in destruction of field mice	352	18-19
Jars, fruit, kinds, description, etc	359	8
opening	359	16
Junket, preparation, uses, etc	363	38
Kale, thousand-headed, feed for dairy cows, value, digestibility, etc.	360	30-31
Kansas, meadow fescue, culture, value, etc	361	8-16
Kitchen, cleanliness of utensils and person, importance	375	43-44
Koch, invention of tuberculin, note	351	3
Kohl-rabi, canning, directions	359	14
Kumquats, growing in Texas, experiments	374	8-9
Labor, dairy farm, requirements, cost, etc	370	32-33
farm, hours, wages, and cost of board in Minnesota	366	30-32
wages on Washington dairy and poultry farm	355	8-9
hours, wages, and cost of board on Minnesota farms	366	30-32
Lambs, feeder, classes and grades	360	24-26
grades for mutton, market requirements, etc	360	18
"hothouse," market requirements	360	27-28
losses at lambing time, prevention	374	22-24
Lamps, brooder house, danger	357	12-13
Land, clearing for irrigation, methods	373	10-13
new, preparation for onion crop	354	9
Lands, hay, increase in value by States, table	362	13-14
irrigated, drainage	371	1-52
Lantz, David E., bulletin on "How to destroy rats"	369	1-20
Laundry, power, for farm	353	31-32
Lawns, spraying for weeds	360	17
"Lazy bed," method of growing potatoes under straw	353	10
Leaf-spot, peanut, description, remedy	356	39
Leek, description, cultivation, etc	354	30
Legume crop, value in rotation for timothy hay	362	8
Legumes, effect on soil compared with timothy crop	362	15
Lemons, growing in Texas, experiments	374	8
Levelers, use in preparing land for irrigation, and description	373	21, 22, 23
Lice, chicken. *See* Mites.		
Lightning and lightning conductors	367	1-20
rods, connections, terminals, and adjustments	367	16-18
for farm buildings	367	14-20
Lima beans, canning, directions	359	14
Lime for alfalfa	374	5-7
"Liquor cresolis compositus," use as disinfectant for poultry	357	34-36
Live-stock farming, planning, considerations, etc	370	17-19
feeding on farms of various types	370	11, 18-21, 23-26, 28-31
importance in potato farming	365	19, 23-24
raising on South Carolina cotton farm	364	17-18
Logging, skidding, floating, hauling, etc	358	25-28
Long Island, potato growing	365	16-17

	Farmers' Bulletin No.	Page.
Louisville, milk supply, methods, etc	366	22–24
Lumbering, conservative, methods, suggestions, etc	358	22–29
Machine, ice, for the home, use, etc	375	29
peanut-picking, description, value, etc	356	24–25
Machines, milking, effect on individual cows	366	19–20
Maggot, onion, control measures	354	35
Maine, Aroostook County, potato growing, methods	365	7–15, 16
poultry management at agricultural experiment station	357	1–39
Mammals, enemies of field mice	352	21–22
rats	369	9
Mangolds, feeding to poultry, method	357	33
Manure, application to potato fields	365	24–25
barnyard, use in onion culture	354	11–12
dairy farm, management	355	12
use in potato growing	365	19
Manures for timothy hay	366	6–10
Market, Pacific Coast for winter lambs	374	25
sheep, classes and grades	360	17–18
Marketing fowls, killing, dressing, etc	353	12–14
onions, methods	354	27–29
potatoes, methods in Maine	365	7–8
Markets, food, sanitation, suggestions, etc	375	20–22
McClure, Harry B., bulletin on "Conditions affecting market hay"	362	1–29
Meadow fescue, culture and uses	361	1–22
hay, rotation of crops, suggestions	362	20
Meal, peanut, uses	356	33
Meats, fresh, care in the home	375	38–39
keeping at home, suggestions	375	33–34
quality, prices, etc	375	23
vegetarian, use of peanuts, note	356	33
Medic, black, description of seeds	353	6
harmfulness by adulteration of clover seed	353	5, 6
Medicago lupulina. *See* Medic, black.		
Mesquite tree, removal from land, cost, methods, etc	373	11–12
Mice, field, control methods	352	13
destruction to vegetation	352	6
habits, nature, etc	352	11
natural enemies	352	21–22
Michels, John, description of cheap ice box for farm	353	29–31
sterilizer for milk vessels	353	27–29
Michigan, potato growing	365	18–20
Micro-organisms, use against rats, remarks	369	18
Microtus montanus, distribution, habits, etc	352	12
Milk, "blended," application of term	363	19
cans, cause of sour milk	366	23
rusty, effect on coagulation of milk	353	18–19
care in the home	363	20
certified, definition and value	363	19
value, etc., compared with other market milk	366	26–27
Chicago, conditions	366	21–22
"clarified," application of term	363	20
clean, production, requirements	366	25
coagulation in cheese making, effect of glass, metals, etc	353	17–19
commercial, classification proposed	366	27–28
composition and characteristics	363	9–15
variations	363	13–14
condensed, preparation, uses, etc	363	18–19
consumer, suggestions	366	20–21
cooked, digestibility compared with raw milk	363	23–25
effect on infants	363	24
depots, condition, Chicago and Louisville	366	21–22, 23
digestibility	363	20–26

	Farmers' Bulletin No.	Page.
Milk, dirt in, effects, prevention, etc	363	14–15
distribution to customers, methods	363 366	15 22–24
dried, preparation, uses, etc	363	18–19
fermented preparations, uses, etc	363	41
flavor, influences	363	14
grading, importance, suggestions	363	19
homogenized, use of term	363	25–26
"hygienic," application of term	363	19
impure, causes	366	20–21, 22, 23–24
Louisville, conditions	366	22–24
mare's, uses	363	25, 41
mineral content	363	11
modified, use of term	363	25
nutrients, cost compared with other foods	363	33–35
nutritive value compared with other foods	363	27–32
powdered, preparation, uses, etc	363	18–19
preparation for delivery, directions	366	26
preservation, methods	363	15–18
products, composition and fuel value	363	36–38
profit of producer, Louisville	366	23
protein compounds	363	10
purity and effect on health, some conclusions	366	27
sales, distribution of returns, Louisville	366	23–24
"sanitary," application of term	363	19
skim, use in feeding chickens	355 357	36 20
sour, uses, value, etc	363	41
sources and kinds, composition	363	8–9
specific gravity, freezing point, etc	363	12–13
"standardized," application of term	363	19
supply of cities	366	20–28
transmission of diseases, caution	363	15
use as food	363	1–44
vessel sterilizer, cheap and efficient	353	27–29
vessels, care, requirements for clean milk	366	25
rusty, effect on milk	353	19
Milking, clean, requirements	366	25
machine, effect on individual cows	366	19–20
MILNER, R. D., bulletin on "The use of milk as food"	363	1–44
Minnesota farms, wages, hours of labor, and cost of board	366	30–32
Mites, chicken, control measures	355	23–25
on hen and brood	357	8
use of cresol and its compounds	357	34–36
MOHLER, JOHN R., bulletin on "The tuberculin test of cattle for tuberculosis"	351	1–8
Molds, food, cause, prevention, etc	375	7–10
Morning-glory, wild. *See* Bindweed.		
Mortar, quality for cement structures in alkali sections	353	21
Mound-building prairie ant, description, habits, harmfulness, etc	353	15–17
Mouse, black, distribution, damage, etc	352	12
plague, Nevada, 1889–92	352	10–11
1907–8	352	1–23
control methods	352	8–9
outbreak in Nevada, history	352	5–7
plagues, origin and progress	352	11
Muck soils, large nitrogen content	366	5–6
treatment	366	5–6
use in onion culture	354	8–9
Mulch, use in growing seed potatoes	353	8–9
Musca domestica, carrier of disease germs, suggestions, etc	375	15–17
Muscadine grapes, pruning	374	11–12
Mus norvegicus, history, life habits, etc	369	5–6

	Farmers' Bulletin No.	Page.
Mustard, wild, eradication by spraying, directions	360	16
Mutton sheep, classes, grades, etc	360	18–24

Nebraska, meadow fescue, culture, value, etc	361	8–16
Nests for sitting hens, arrangement, etc	357	6–7
trap, construction, value, etc	357	36–39
use in selecting breeding stock	357	5
Neufchatel cheese, note	363	39
Nevada, mouse plague, 1907–8	352	1–23
New York, potato growing, methods	365	16–18
Nielsen, H. T., and C. V. Piper, bulletin on "Soy beans"	372	1–26
Nitrate of soda, use in top dressing onion crop	354	13
North, potato-growing sections, farm management	365	1–31

Oat rust, enemy to meadow fescue	361	14
Oats, feed for work horses, experiments	374	25–26
growing on South Carolina cotton farm	364	16
Ogden drainage experiment, Utah, results, etc	371	20–22
Oil, peanut, value, and uses	356	33, 34
Okra, canning, directions	359	13
Olson, G. A., experiments on effect of glass, metals, etc., on the coagulation of milk	353	17–19
Onion, climatic and soil requirements	354	6–8
crop, tillage, methods, requirements, etc	354	17–19
time required for production	354	7
United States, value, yield, etc	354	5–6
culture	354	1–36
Egyptian, growing in Mississippi valley, note	354	6
enemies, diseases, insects, etc	354	33–36
growing, moisture requirements	354	7
habitat, history, uses, etc	354	5–6
maggot, control measures	354	35
potato, description, note	354	30
seed, Northern grown, advantages	354	7
planting, amount to acre, etc	354	14–16
sets, planting, amount to acre, etc	354	17
thrips, control measures	354	35
Onions, Bermuda, growing, cost, profits, etc	354	30–32
harvesting, marketing, etc	354	30–32
green for bunching, growing, marketing, etc	354	32–33
harvesting and curing	354	21–24
importations	354	5
varieties, important commercial	354	29–30
weight per bushel	354	29
Ophthalmo tuberculin test, results, etc	351	4
Orange culture, Texas, experiments	374	7–8
Satsuma, hardiness, experiments	374	8
Oranges, mandarin type, growing in Texas, outlook	374	10–11
varieties suitable for southern Texas, experiments	374	7–8
Orchards, advantages and injury from bindweed	368	6–7
Oregon, kale for dairy cows, value, yield, digestibility, etc	360	30–31
western, value of vetch	360	29–30
Owls, enemies of field mice	352	21–22

Paris green, use in spraying potato crop	365	11–12
Parker, E. C., and T. P. Cooper, study of farm labor in Minnesota	366	30–32
Parsnips, canning, directions	359	14
Pasteurization, milk, method	363	16–17
Pasture, meadow fescue, value	361	12–14
soy bean, value for hogs	372	15–16
Pasturing, use in eradication of bindweed	368	14–17
Peanut butter, directions for making	356	32
candy, directions for making	356	32
crop, 1908, value	356	7
disease, description, remedy	356	38–39

	Farmers' Bulletin No.	Page.
Peanut, farm crop, importance	356	35–38
forage, handling, curing, etc	356	37–38
growing, uses, etc	356	1–40
history, description, etc	356	7–8
hulls, composition, value, etc	356	33
insect injurious	356	38
meal, uses	356	33
oil, industry, outlook, possibilities, etc	356	34
uses, value, etc	356	33–34
plant, forage value	356	36–37
preparations, description	356	32–33
soil, climatic requirements, etc	356	8–9
value as nitrogen gatherer	356	13
in crop rotation in South	356	8
vines, feed value	356	27
Peanut-picking machine, description, value, etc	356	24–25
Peanuts, feeding value compared with other feed stuffs	356	37
fertilizing value of roots	356	20
food use, forms, importance, etc	356	31–33
marketing, preparation	356	26
varieties, description, value, etc	356	27–31
yield per acre	356	40
Pearl, Raymond, bulletin on "Poultry management at Maine Agricultural Experiment Station"	357	1–39
Peas, canning, directions	359	13
Peat soils, use in onion culture	354	8, 9
Peavine. *See* Bindweed.		
Pelt, importance in marketing sheep	360	19
Pennsylvania, indemnity for tuberculous animals	351	7
Pet animals, danger as disease carriers	375	18–19
Phosphorus, use against field mice, results, etc	352	13
rats, methods, caution, etc	369	15–16
Pigs, management on west Washington dairy farm	355	20
Pinchot, Gifford, bulletin on "Practical Forestry"	358	1–48
"Pindar." *See* Peanut.		
Piper, C. V., and H. T. Nielsen, bulletin on "Soy beans"	372	1–26
Stanley E., bulletin on "The Nevada mouse plague of 1907–8"	352	1–23
Pit trap, construction, management, etc	369	13–14
Planer, levee, use in preparing land for irrigation, description	373	14–15
Planter, potato, description	365	9–10
Planting peanuts, time, methods, etc	356	15–17
potato, methods in Maine	365	8–10
soy beans, directions	372	11–12
Plow, disk, use in onion culture	354	10–11
Plowing new land for irrigation, methods, cost, etc	373	12
on worn-out cotton farm	364	9–10
onion culture	354	10–11
peanut culture	356	10–11
Plucking fowls for market	353	12, 13, 14
Point Lookout drainage experiment, Utah, cost, results, etc	371	15–17
Poisoned hay, remedy for field mice	352	8–9, 10
Poisons, rat, recommendations, management, etc	369	14–16
use against field mice	352	13–14
Potato crop, handling	365	20
importance in northern States	365	6–7
digger, use in harvesting peanuts, cost, etc	356	19–20
growing, Maine, methods	365	7–15, 16
Michigan and Wisconsin	365	18–20
profits, Maine	365	14
United States, statistics	365	6
harvesting, methods in Maine	365	12–13
houses, construction, Maine	365	13–14

	Farmers' Bulletin No.	Page.
Potato onions, description, note	354	30
seed, Northern grown, value for Southern growers	365	7
selection	365	26–28
Potatoes, cost of production	365	20–22
destruction by field mice	353	5
growing in Northern sections, farm management	365	1–31
under straw	353	9–10
yield, various sections	365	6,7,19–20,21
Poultry and dairy farm, successful	355	1–40
west Washington, income	355	20, 40
care in the home	375	39
danger from crows	366	28–29
destruction by rats, note	369	9
drawn, comparison with undrawn	375	23–24
houses, building, arrangement, cost, etc	374	26–30
construction of various kinds, cost, etc	357	20–21
curtain-front, construction	357	22–31
description, cost, etc	355	21–23
management, Maine Agricultural Experiment Station, methods	357	1–39
of west Washington dairy and poultry farm	355	21–40
marketing, killing, dressing, etc	353	12–14
raising, colony houses	374	26–30
hens compared with incubators, experiments	353	10–12
Maine	357	1–39
yards, suggestions	357	31
Prairie ant, mound-building, description, habits, harmfulness, etc	353	15–17
Preservation, eggs, selection, care, etc	353	14–15
milk, methods	363	15–18
Preservative, water glass for eggs, preparation	353	14–15
Preservatives, milk	363	15–18
"Preserving powders," caution	359	8
Propagation, onions	354	14–17
Protein compounds of milk	363	10–11
Pruning grape vines, sap lost at different seasons, table	374	12
rotundifolia grapes	374	11–12
street trees, importance, mistakes, etc	360	14
Ptomaine poisoning, sources, cautions, etc	375	11–12
Puccinia coronata, enemy to meadow fescue	361	14
Pullets, April, value as layers	357	6
care and management	355	30–32
Pumpkin, canning, directions	359	15
Quack-grass, extermination in potato fields	365	15
Rabbits, destruction of soy bean crop, note	372	7
Rainfall, conservation by forests, etc	358	35–40
Rams, market classes and grades	360	24, 27
Rat bait, recommendations	369	11
brown, history, life habits, etc	369	5–6
Norway, history, life habits, etc	369	5–6
traps, description and management	369	11–14
Rats, danger as disease carriers	375	18–19
destruction, fence and battue method	369	14
methods	369	1–20
value of organized efforts, suggestions, experiments, etc	369	19
enemies, natural	369	9–10
exclusion from buildings, management	369	6–9
house, species, note	369	5
Red clover hay, nutritive content	362	17
Redtop hay, nutritive content	362	17
Refrigerators, home, description, care, etc	375	29–30
Restaurants, public, importance of cleanliness	375	45–46

	Farmers' Bulletin No.	Page.
Richfield drainage experiment, Utah, cost, results, etc	371	32–35
Ridger, use in preparing land for irrigation, description	373	15
Roosting houses, construction	357	21–22
Root crops, destruction by field mice	352	5
Rotation, crop, for onion culture	354	9
potato growing in Maine	365	8
Rotundifolia grapes, pruning	374	11–12
Rust, enemy to meadow fescue	361	14

Sagebrush, removal from land for irrigation, methods, cost, etc	373	10–11, 12
Salt sickness of cattle	366	17–19
Saltbush, nutritive value, experiments	374	15–16
Sandstone, effect of alkali	353	21
"Sanitary" milk, application of term	363	19
Satsuma orange, hardiness, experiments	374	8
Scab, potato, preventive measures	365	17, 25
Schools, forestry	358	42, 48
Scourge. *See* Plague.		
Scrapers, use in preparing land for irrigation, descriptions	373	21, 26
Screenings, wheat, use as feed, danger from weed seeds	366	16–17
weed seed content, analysis	366	16–17
Scuppernong grapes, pruning	374	11–12
Seed, alfalfa, dodder infested, methods of screening, etc	353	7–9
production under irrigation	373	47
clover, commercial, adulteration, vitality, etc	353	5–7
light compared with heavy, number per pound, etc	353	5
management of crop	370	13–15
production on potato farms	365	25–26
purity, importance	353	6
meadow fescue, sowing, production, demand, etc	361	8–12
onion, Northern grown, advantages	354	7
planting, amount to acre, etc	354	14–16
peanut, importance, selection, etc	356	13–15
quantity per acre	356	16
potatoes, growing under straw	353	9–10
selection	365	19, 26–28
treatment to prevent scab	365	17
soy bean, harvesting, difficulties and suggestions	372	19
selection	372	12
storage, directions	372	22
tall fescue, value, production, etc	361	19–20
Seeding alfalfa, on land to be irrigated, directions	373	43–44
Seeds, black medic, adulterant of clover seed, description	353	6
weed, harmful use in adulteration of clover seed	353	6
Sheep, breeding, market classes and grades	360	27
dead in transit, value, etc	360	28
farm, management, returns, etc	370	17–23
feeder, classes and grades	360	24–27
feeding value of soy beans, experiments	372	20–21
injury to flock by dogs	374	24
losses at lambing time, prevention	374	22–24
market classes and grades	360	17–18
native, definition	360	18
raising, feeding, management of flock, etc	370	19–23
use in eradication of bindweed	368	17
Western, definition	360	18
Shipping onions to market, methods	354	28–29
Silage crops, west Washington	355	11–12
dairy farm, west Washington, materials, management, etc	355	11–12
filling silo, method	355	11–12
vetch and vetch hay, for cows	360	29–30
without silo, use of barley, management	355	11
Silo, combination stone and stave, construction	353	24–26
construction	353	22–27
Silos, concrete, construction	353	26–27

	Farmers' Bulletin No.	Page.
Silos, failures, causes	353	22–24
material for construction	353	24–27
Silt, injury to alfalfa, remedy	373	46
Silviculture, systems	358	8–20
Simpson, Dr., explanation of electricity in thunderstorms	357	12
Skidding, care, suggestions, etc	358	25–26
Skim milk, nutritive value, uses, etc	363	29–35
use in feeding chickens	355 357	36 20
Skunk, enemy of field mice	352	21–22
Slaughterhouses, country, relation to rat pests	369	9
SMITH, C. BEAMAN, and J. W. FROLEY, bulletin on "Replanning a farm for profit"	370	1–36
Smut, onion, description, remedies, etc	354	33–34
Soap, cresol, manufacture, value as disinfectant, etc	357	34–36
Soil fertility, maintenance in Northern potato-growing sections	365	23–24
onion, requirements	354	30
Soiling crops, West Washington dairy farm	355	15–17
Soils, citrus fruit growing in Texas, selection, preparation, etc	374	9–10
muck, treatment	366	5–16
onion culture, requirements	354	7–8
Soja bean. *See* Soy bean.		
Sorghum, sweet, mixed crop with soy beans, management	372	17
Sorgo and soy beans, mixed crop, management	372	17
South Carolina, cotton farm, methods, etc	364	1–23
peanut industry, extent	356	8–9
Southern hay trade, demands	362	9
Soy bean, climatic and soil requirements	372	6–7
hardiness under climatic conditions	372	7
Soy beans	372	1–26
comparison with cowpeas	372	24–25
feeding value, comparison with cotton-seed meal	372	23–24
growing in mixtures, suggestions	372	16–17
varieties	372	7–11
SPILLMAN, W. J., bulletin on "A successful poultry and dairy farm"	355	1–40
Spraying for weeds	360	15–17
potato crop, methods in Maine	365	11–12
Sprays, potato crop, preparation, application, etc	365	11–12
use in eradication of weeds	360	16
Squash, canning, directions	359	13, 15
St. George drainage experiment, Utah, cost, results, proposed extensions, etc	371	35–44
Stags, sheep, marketing, note	360	24
Steel trap for rats, management, suggestions	369	12
Sterilization, fractional, description	359	7
milk, method	363	17
vessels, directions	366	25
theory and underlying facts	359	5–7
Sterilizer for milk vessels, cheap and efficient	353	27–29
Storage, cold, effect on quality of food	375	26–27
food, methods	375	26–32
hot-weather, methods	375	30–32
onions, requirements, house, etc	354	24–27
potato crop, methods in Maine	365	13–14
potatoes, methods	365	20
winter, for the home, suggestions	375	31–32
Storeroom, home, requirements	375	27–28
Straw, peanut, feeding value	356	36
use in growing potatoes	353	9–10
Streams, flow, relation of forests	358	33–40
Street trees, care and preservation	360	9–15
String beans, canning, directions	359	12
Strychnine, use against field mice, results, etc	352	13–14
rats, suggestions	369	15
Stumps, high, losses in logging in Adirondacks	358	24

XX 002 288 648

XX 002 288 648